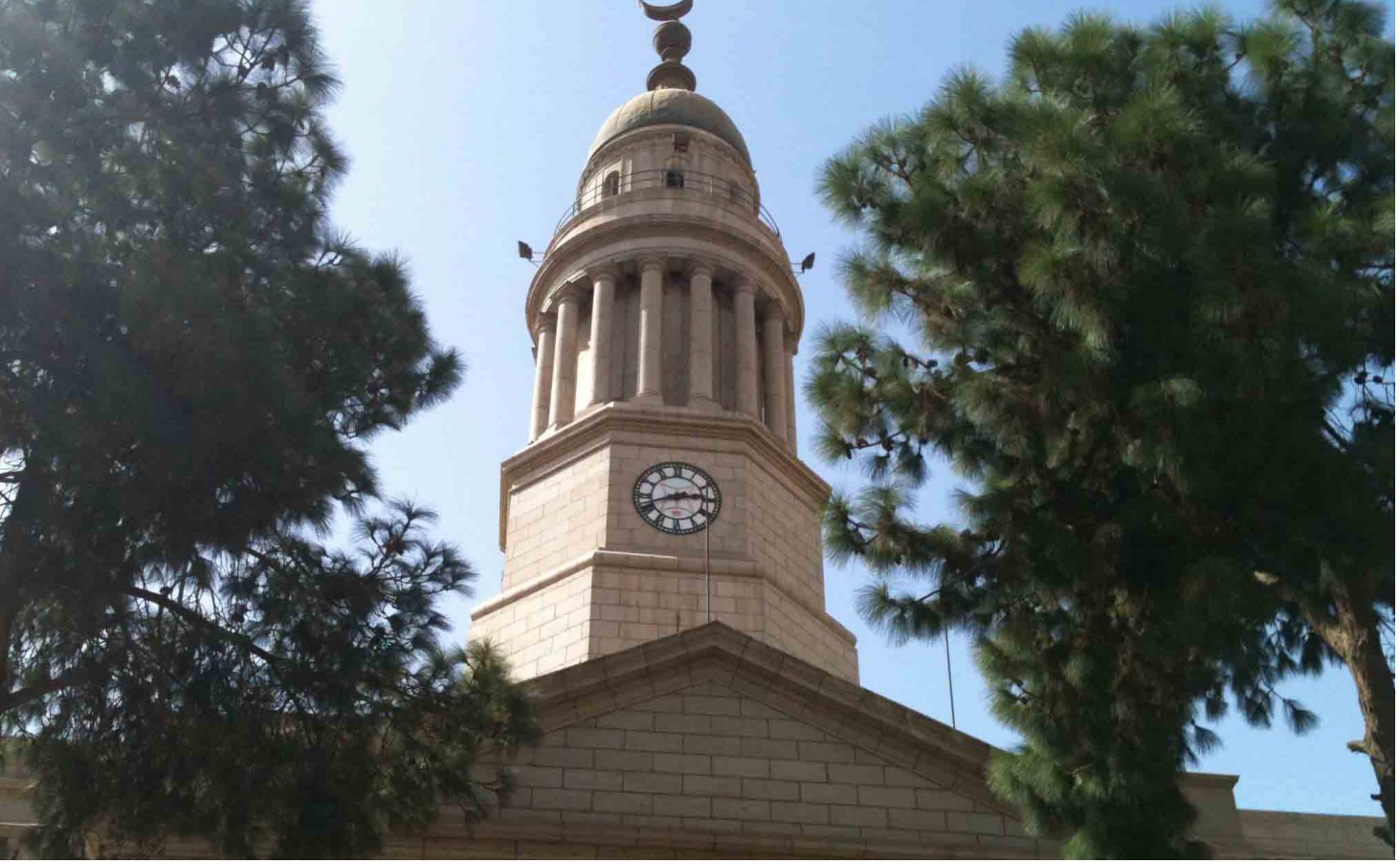

Afferent visual pathway

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2017

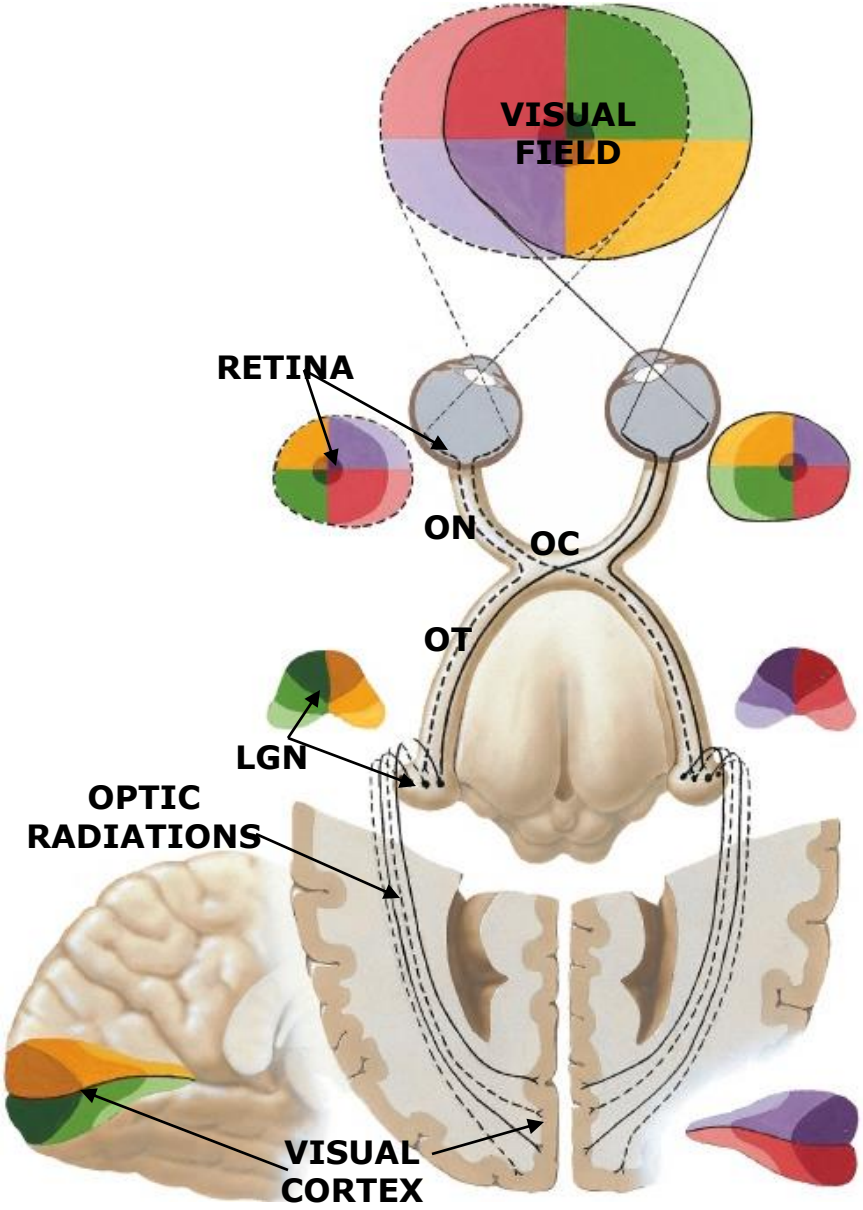
Agenda

- Anatomy of visual pathway
- Visual pathway disorders
- Quiz

Agenda

- **Anatomy of visual pathway**
- **Visual pathway disorders**
- **Quiz**

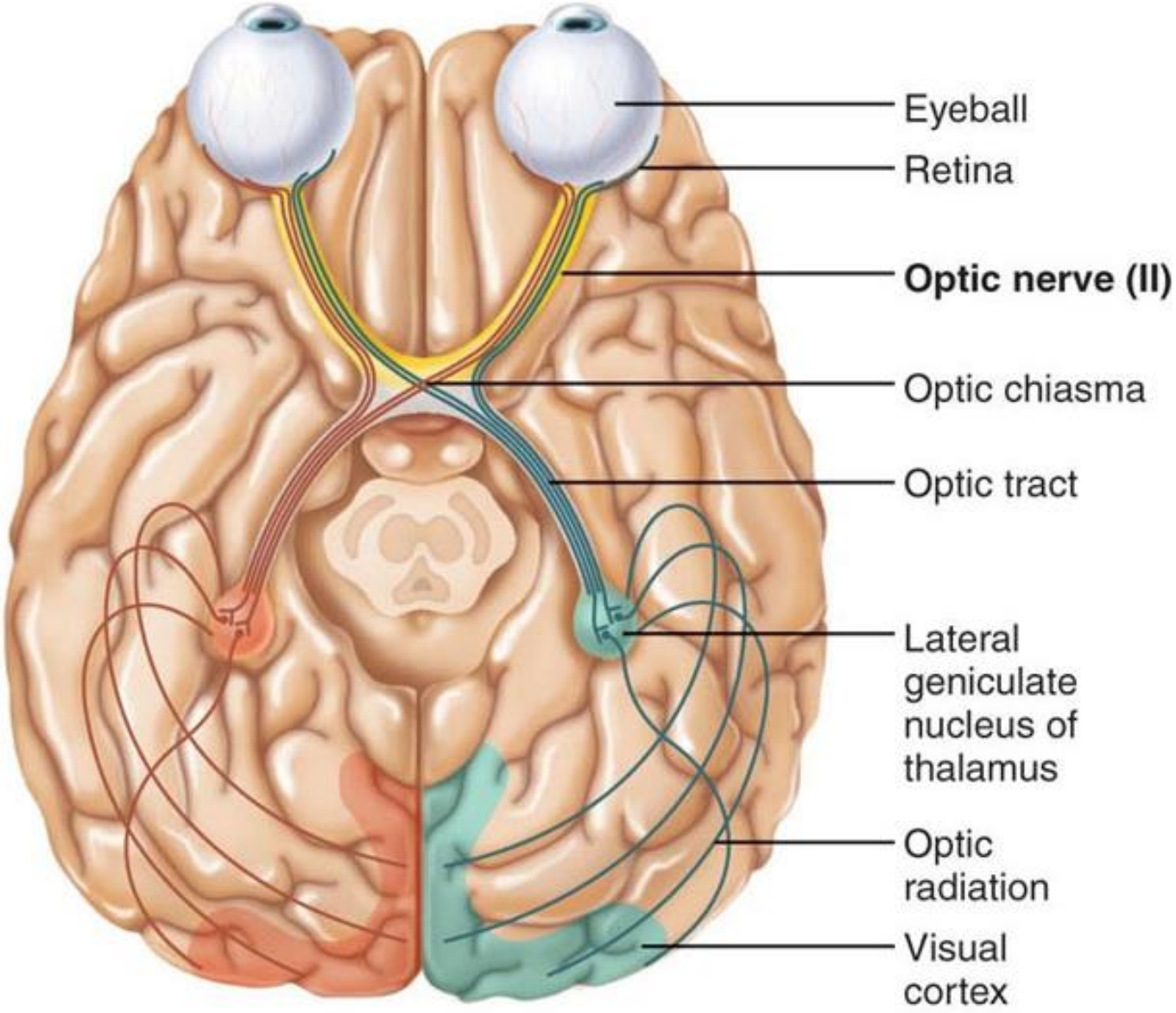
The Visual Pathway



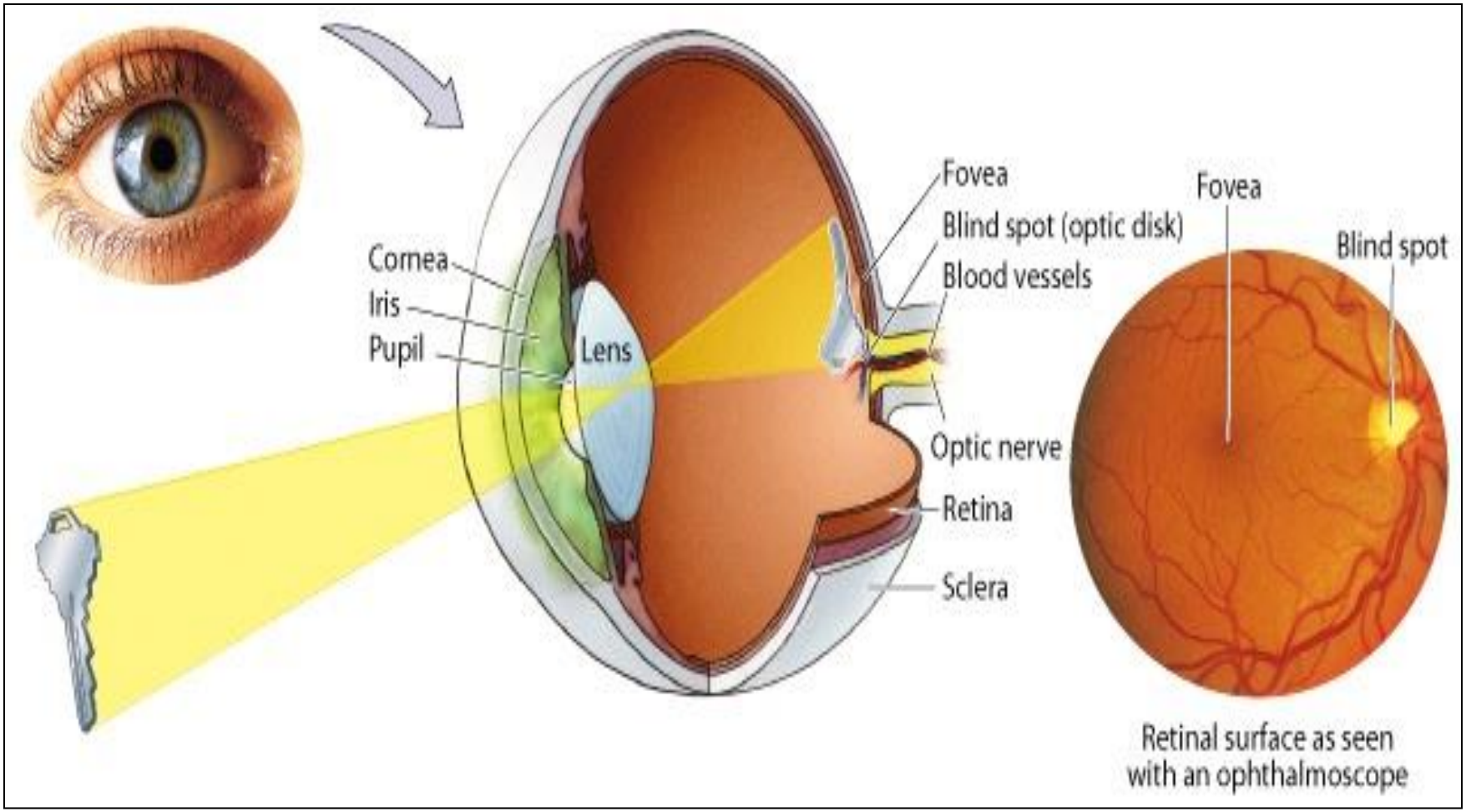
Pathway extends from the 'front' to the 'back' of the brain.

ON = Optic Nerve
OC = Optic Chiasm
OT = Optic Tract
LGN = Lateral Geniculate Nucleus of Thalamus

The Visual Pathway

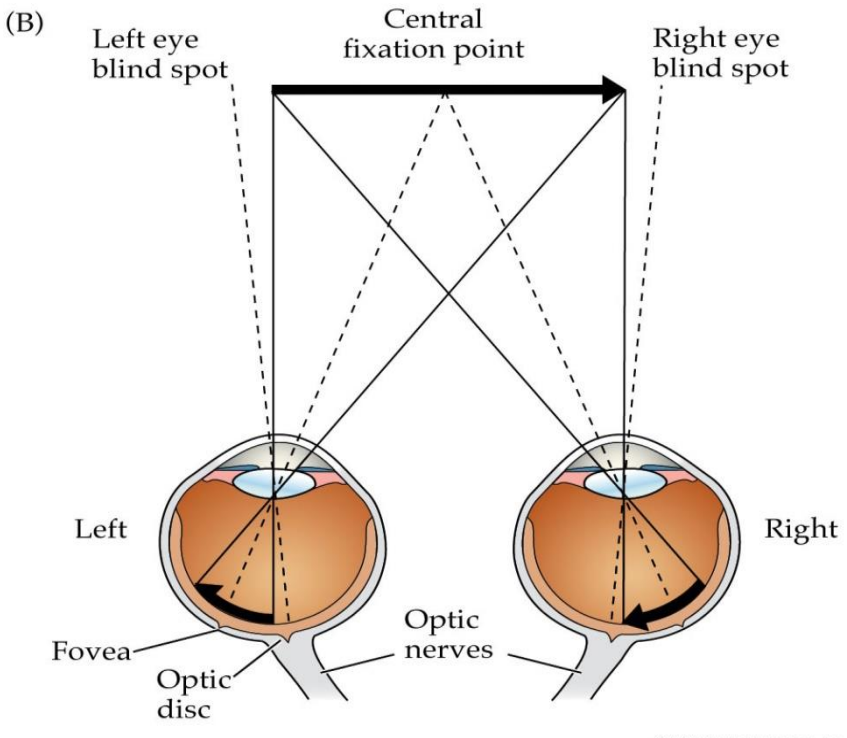


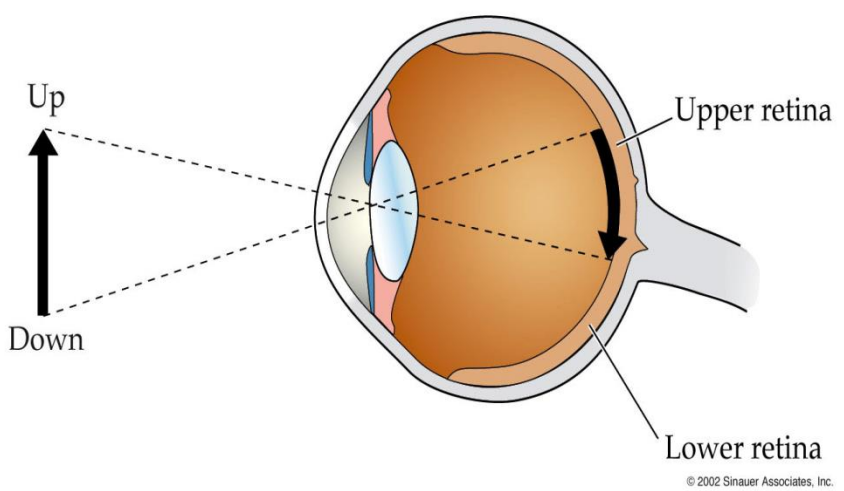
Eyes & Retina



Light >> lens >> retina (inverted and reversed image).

Eyes & Retina


(B)
Left eye blind spot
Central fixation point
Right eye blind spot
Left
Right
Fovea
Optic disc
Optic nerves
© 2002 Sinauer Associates, Inc.


)
Up
Down
Upper retina
Lower retina
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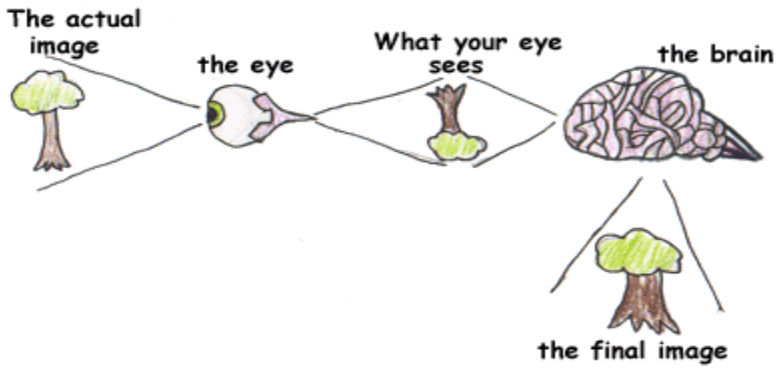
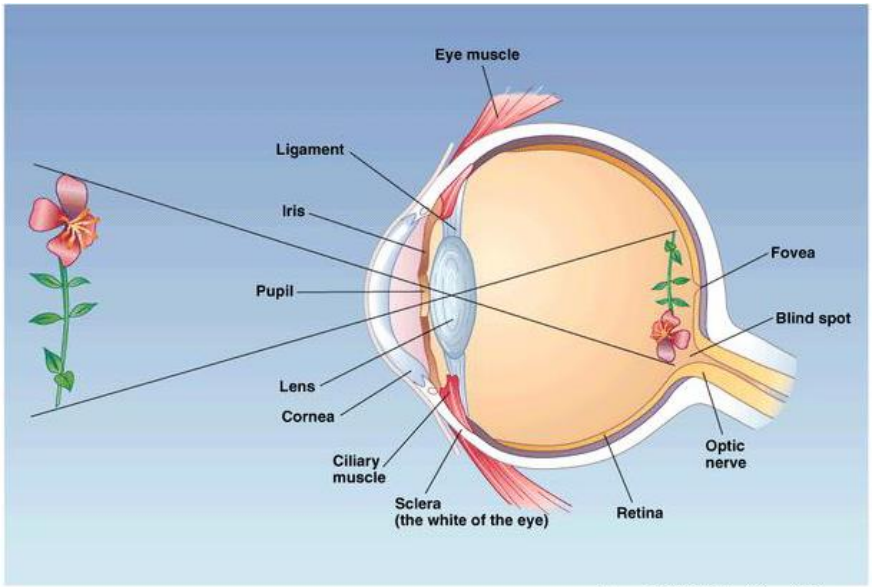
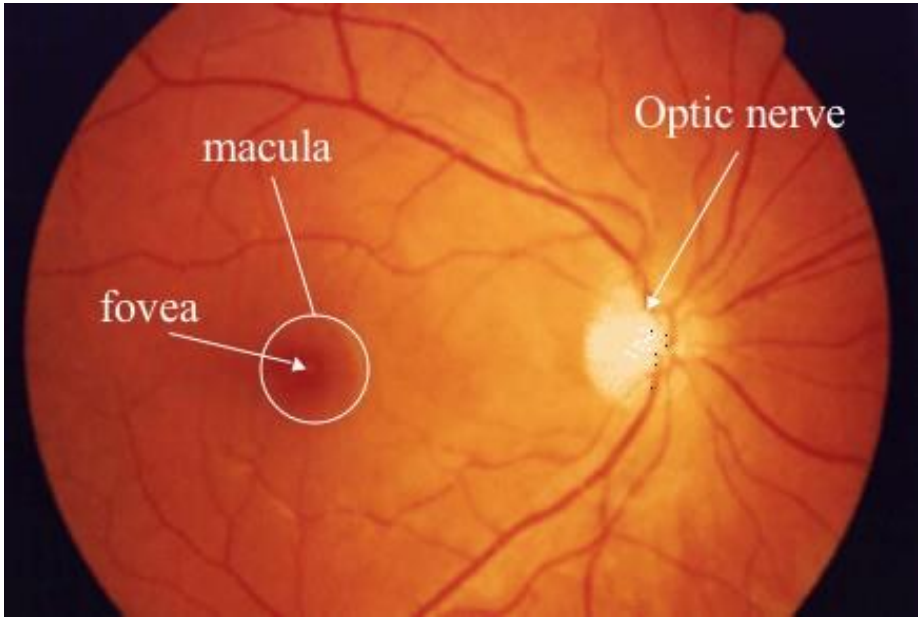

The actual image
the eye
What your eye sees
the brain
the final image


Eye muscle
Ligament
Iris
Pupil
Lens
Cornea
Ciliary muscle
Sclera (the white of the eye)
Retina
Optic nerve
Blind spot
Fovea
Copyright © 2001 by Allyn & Bacon

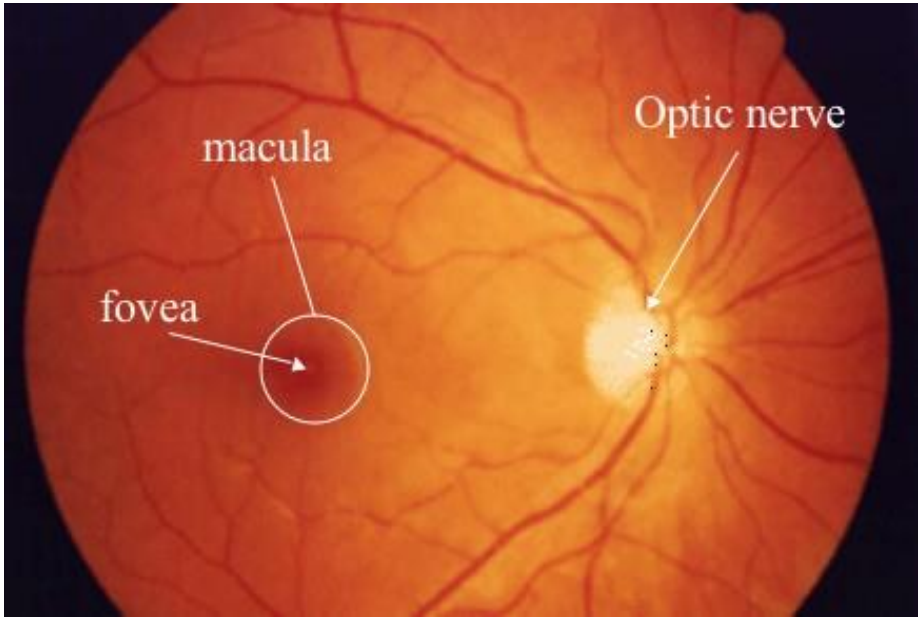
Eyes & Retina

- ***Macula:*** oval region approximately 3-5 mm that surrounds the fovea, also has high visual acuity.
- ***Fovea:*** central fixation point of each eye// region of the retina with highest visual acuity.



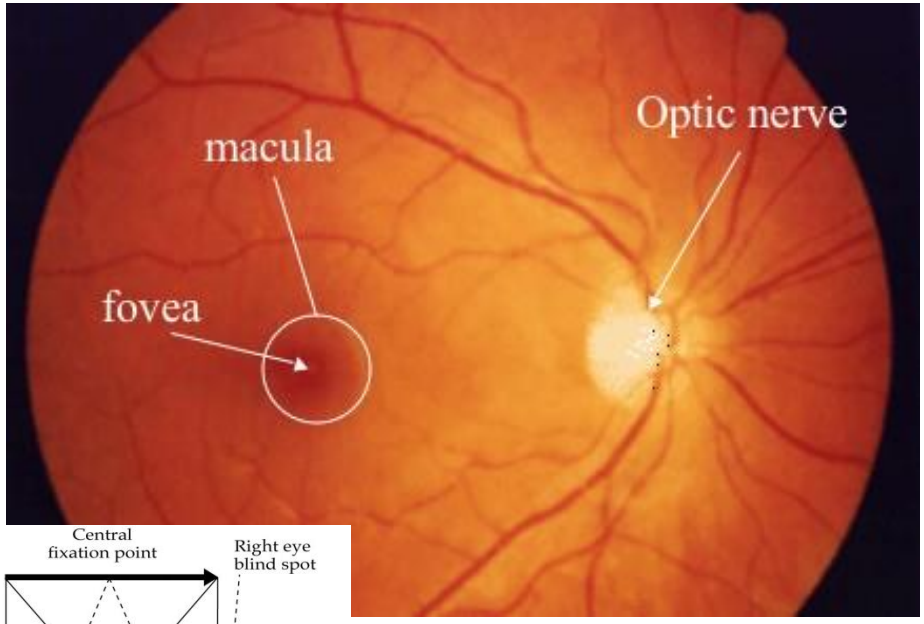
Eyes & Retina

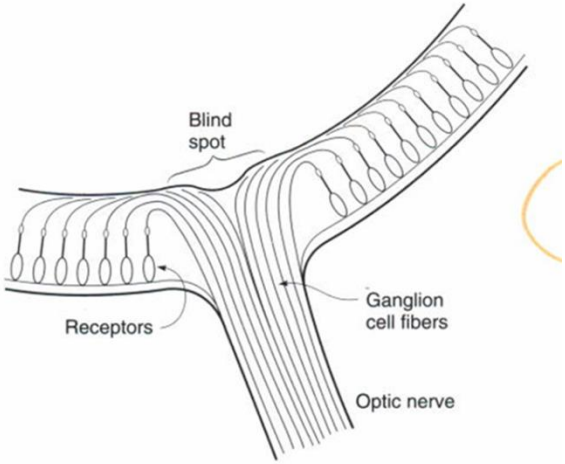
- ***Optic disc:*** region where axons leaving the retina gather to form the ***Optic nerve.***

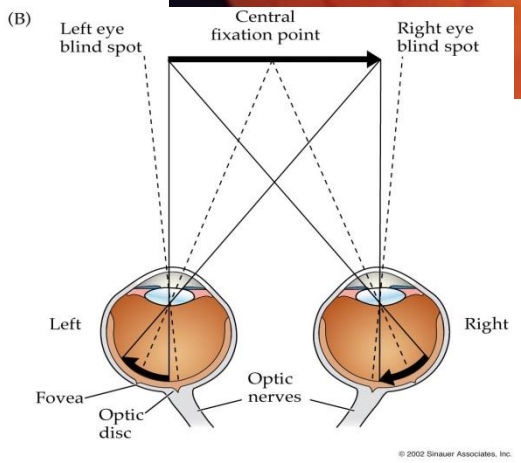


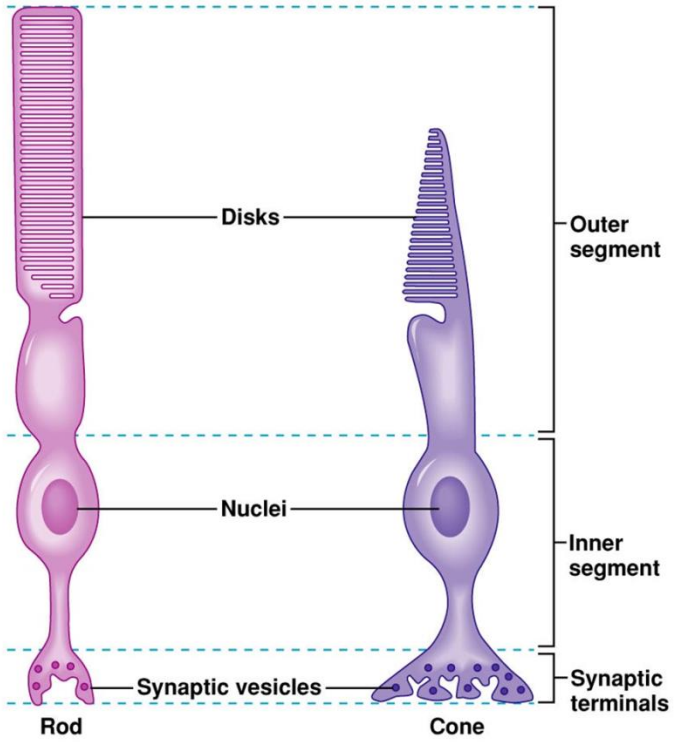
Eyes & Retina

- ***Blind spot*** located 15° lateral and inferior to central fixation point of each eye.





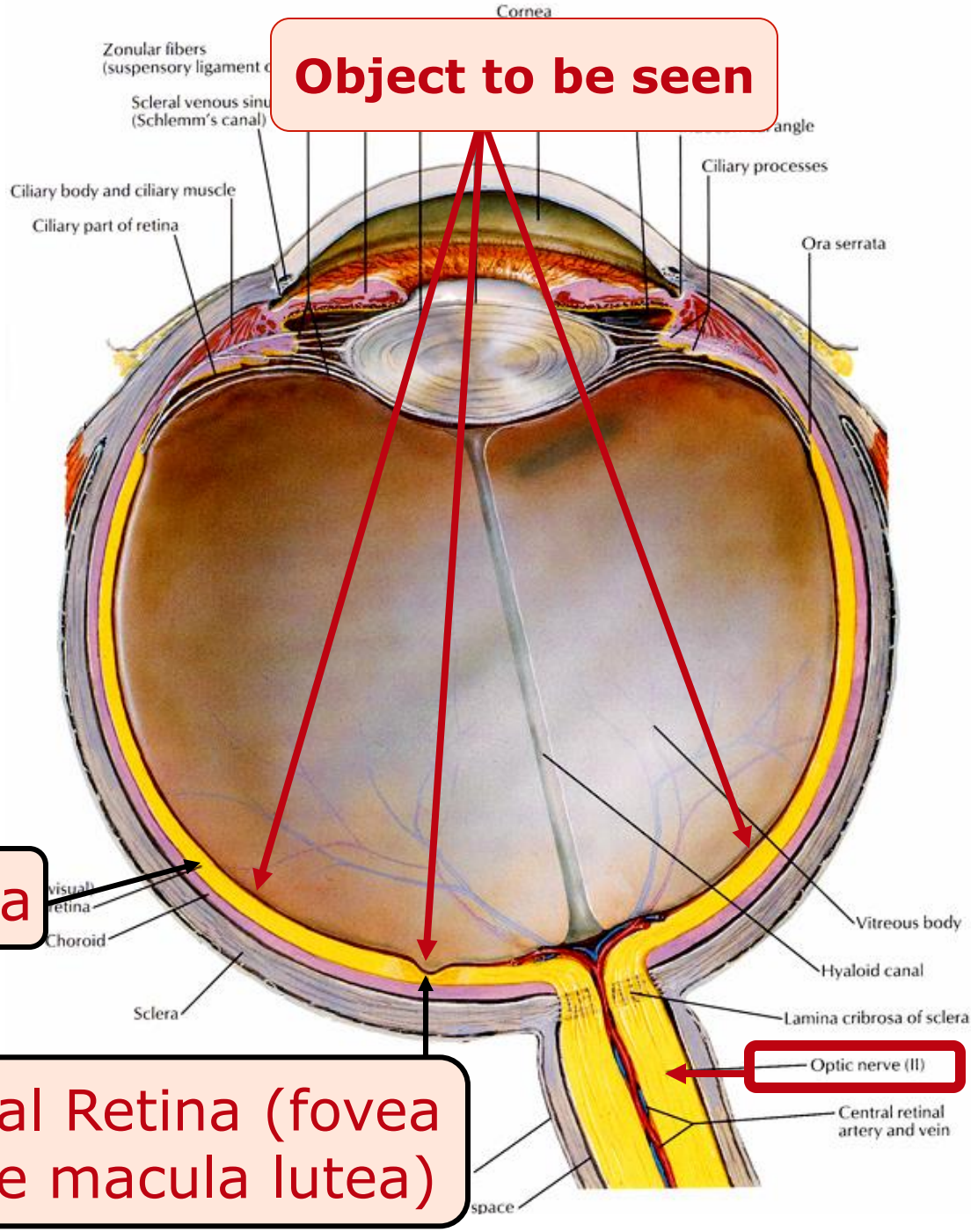




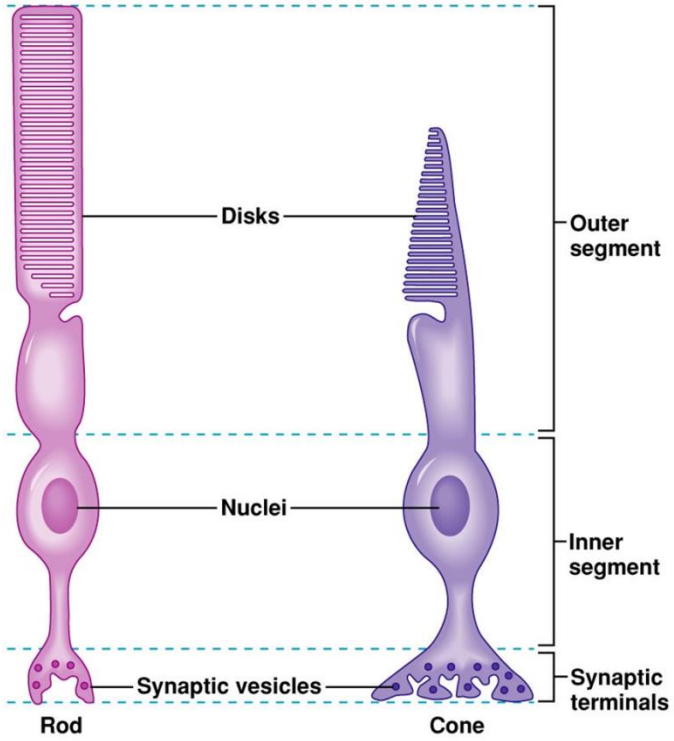
Object to be seen

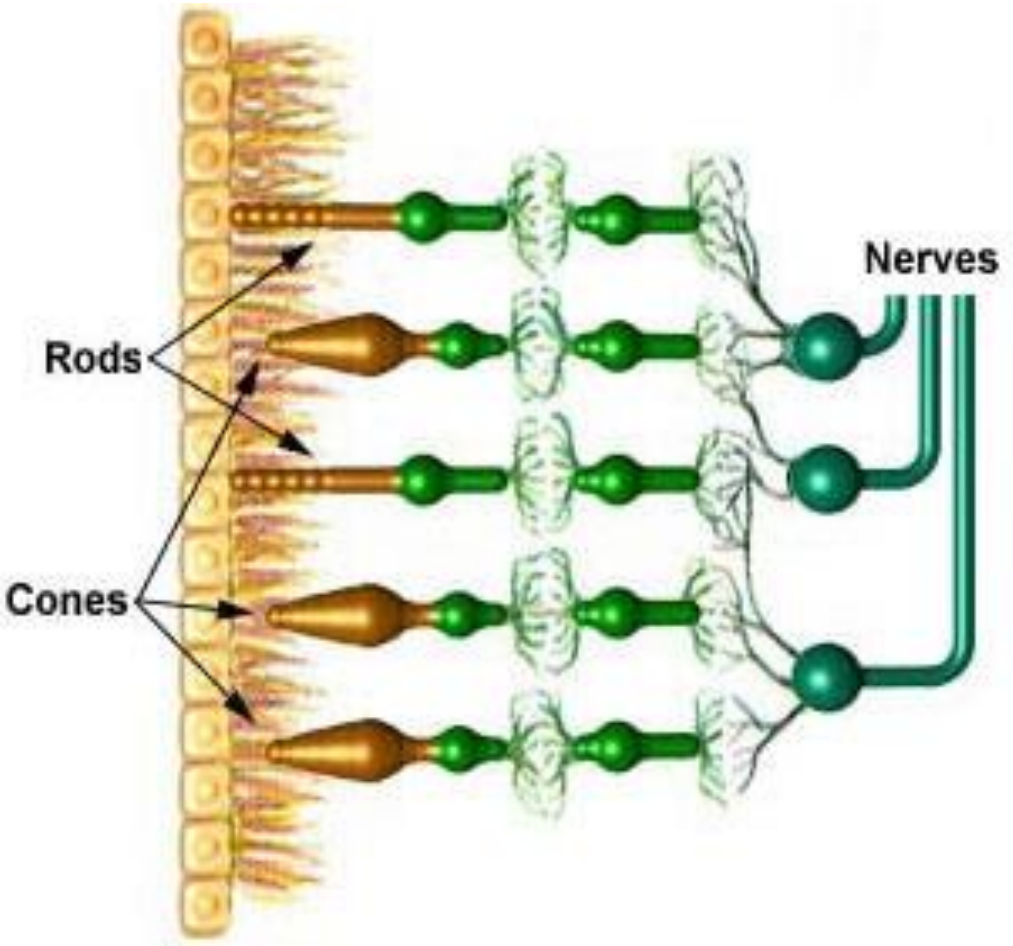
Peripheral Retina

Central Retina (fovea in the macula lutea)



Photoreceptors

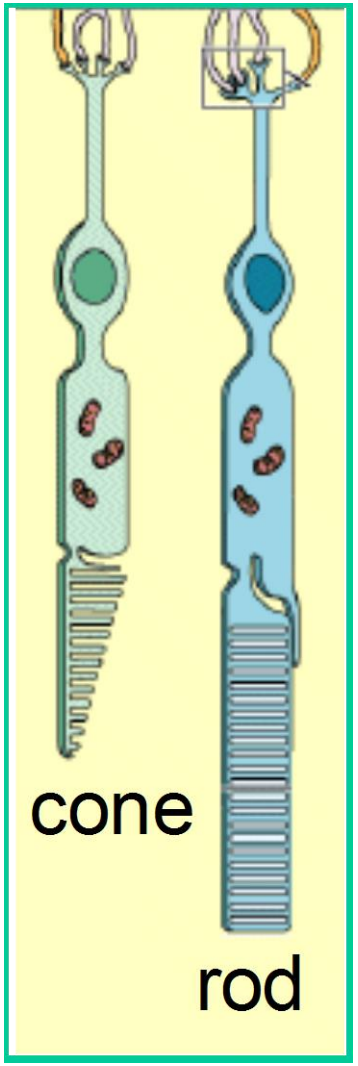




Photoreceptors

Cones

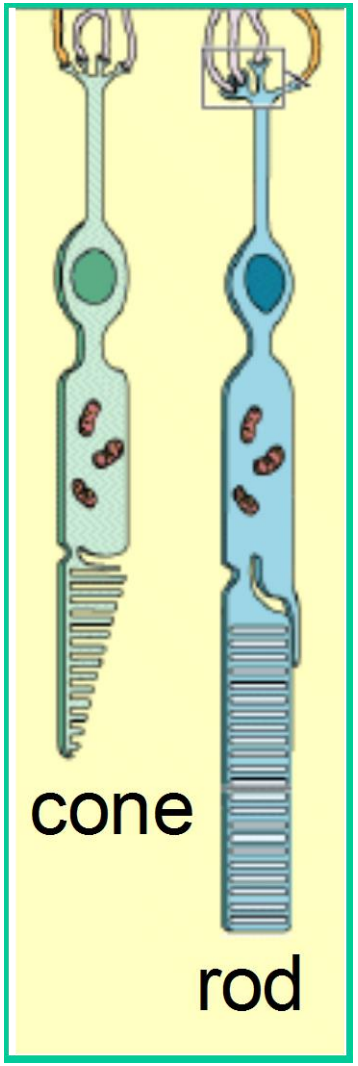
- Cone-shaped
- Less sensitive
- Operate in high light
- Color vision
- Less numerous
- Highly represented in the fovea >> have high spatial & temporal resolution >> they detect colors.



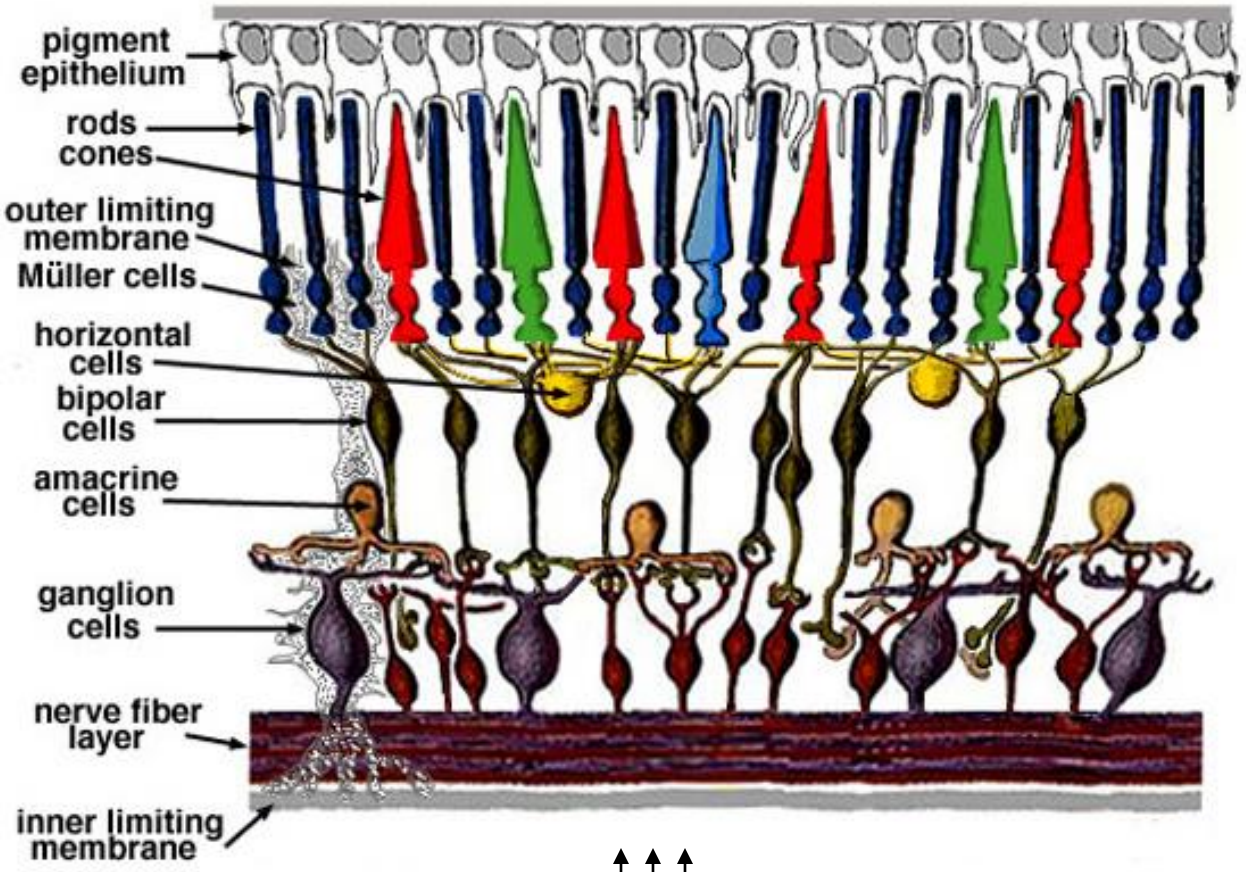
Photoreceptors

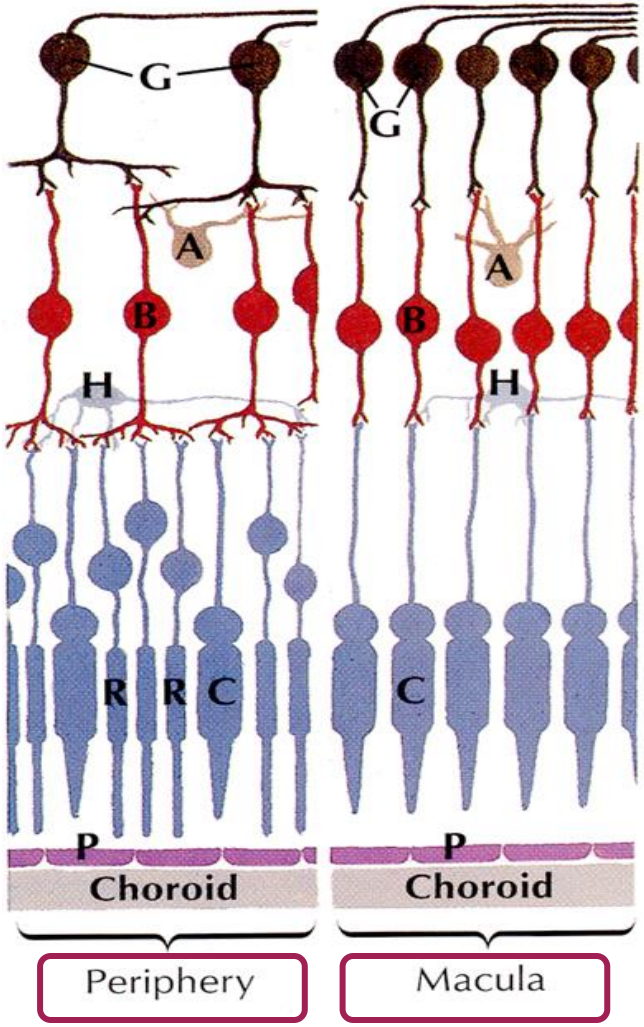
Rods

- Rod-shaped
- Highly sensitive
- Operate at night
- Gray-scale vision
- More numerous than cons- 20:1, have poor spatial & temporal resolution of visual stimuli, do not detect colors >> vision in low level lighting conditions



Retina up-close





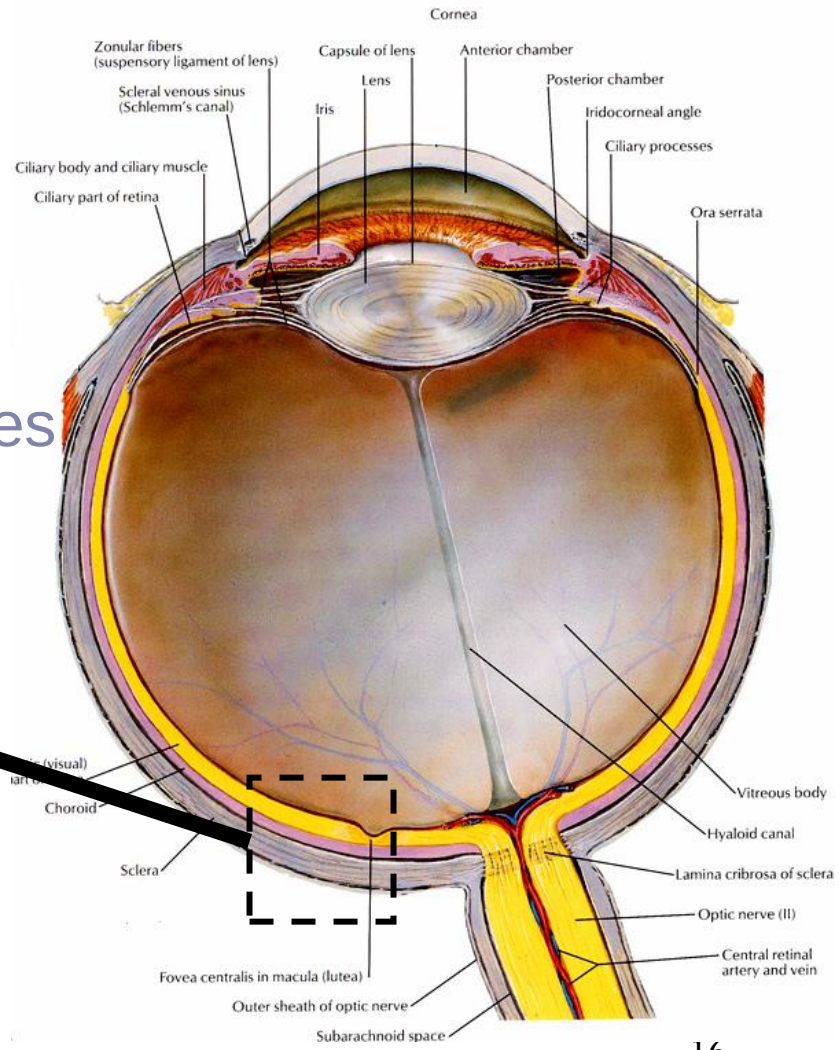
Structure of retina: schema

A	Amacrine cells
B	Bipolar cells
C	Cones
G	Ganglion cells
H	Horizontal cells
P	Pigment cells
R	Rods

Ganglion cells → axons form the optic nerve

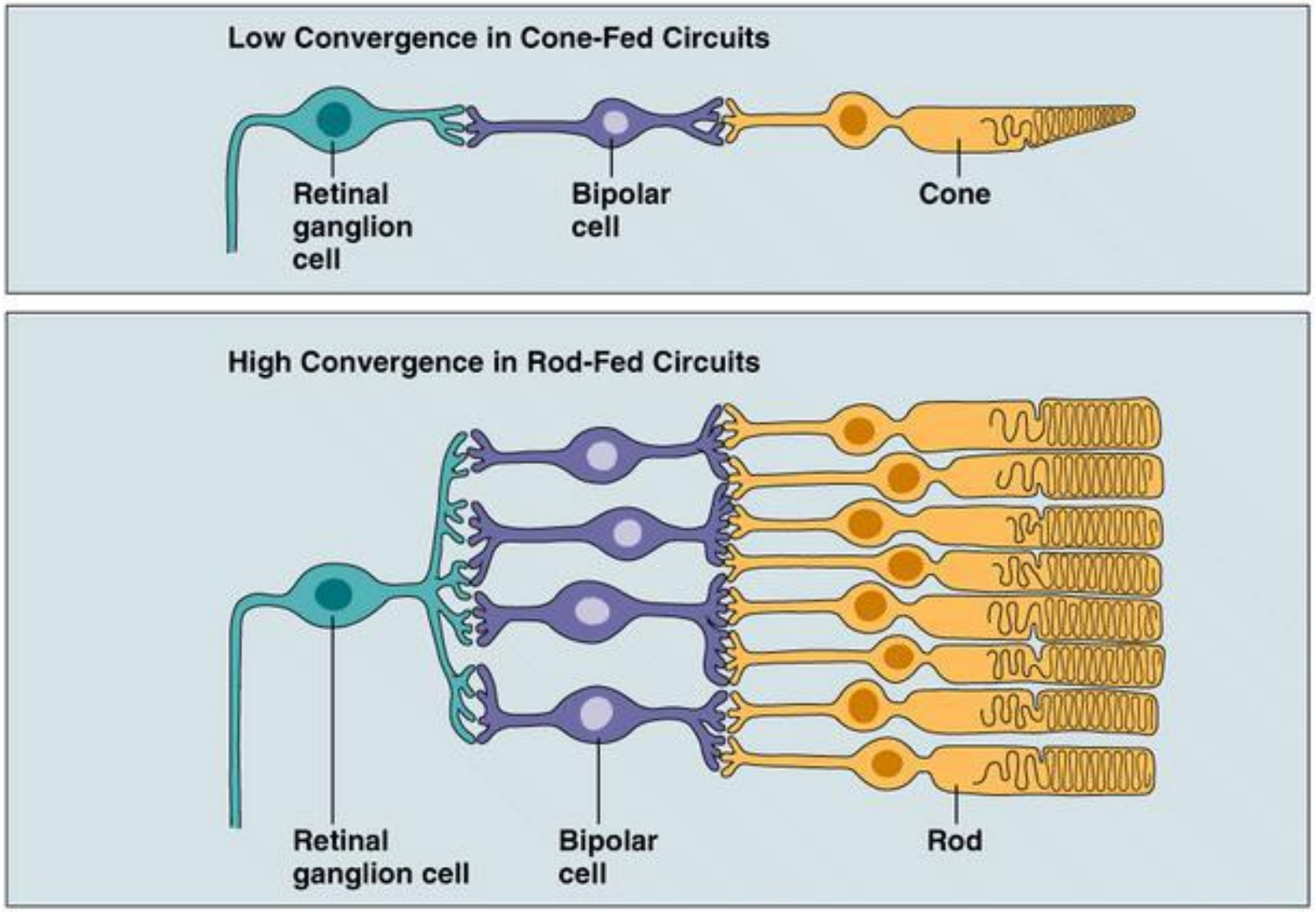
Bipolar cells

Rods and Cones
(Receptors)

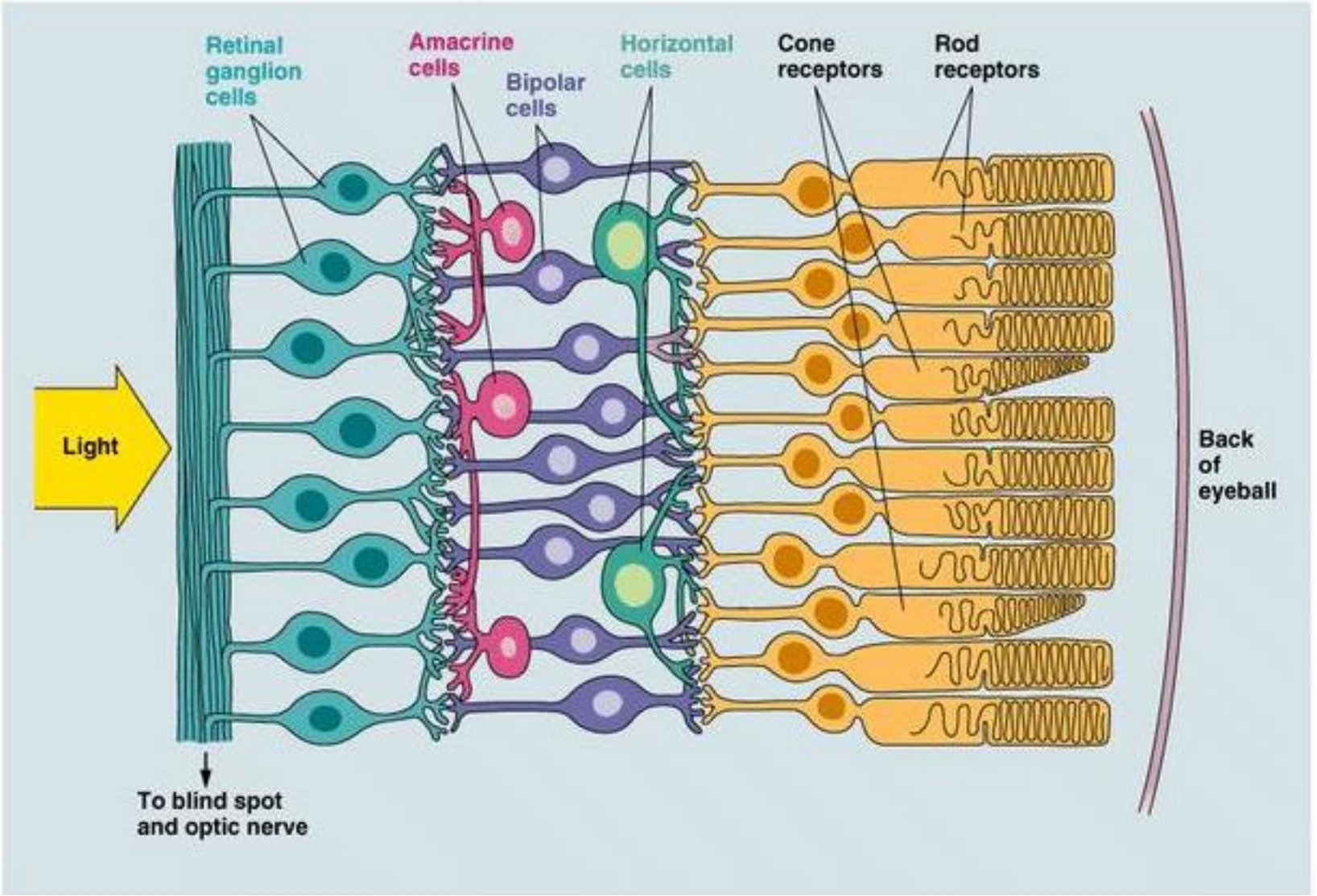


Photoreceptors

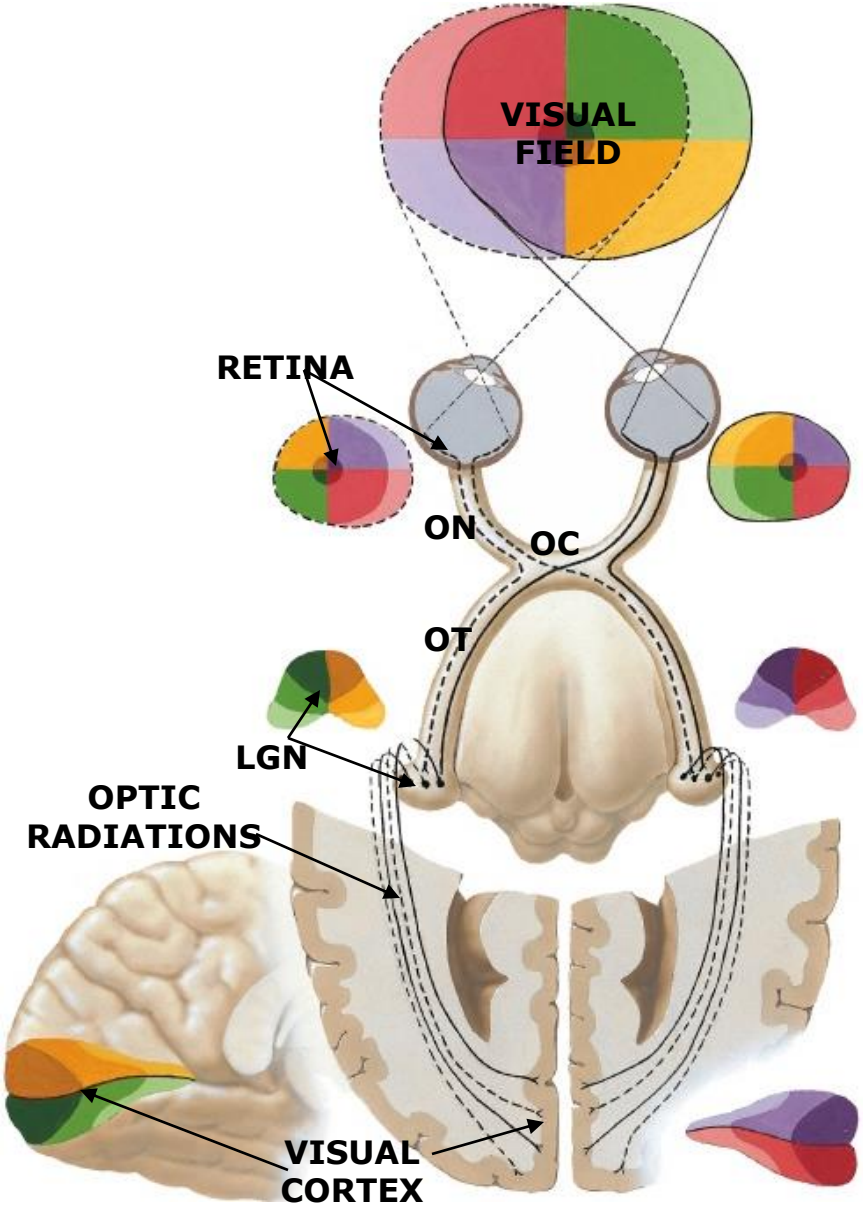
- Convergence of Cones and Rods



Photoreceptors



The Visual Pathway



Pathway extends from the 'front' to the 'back' of the brain.

ON = Optic Nerve
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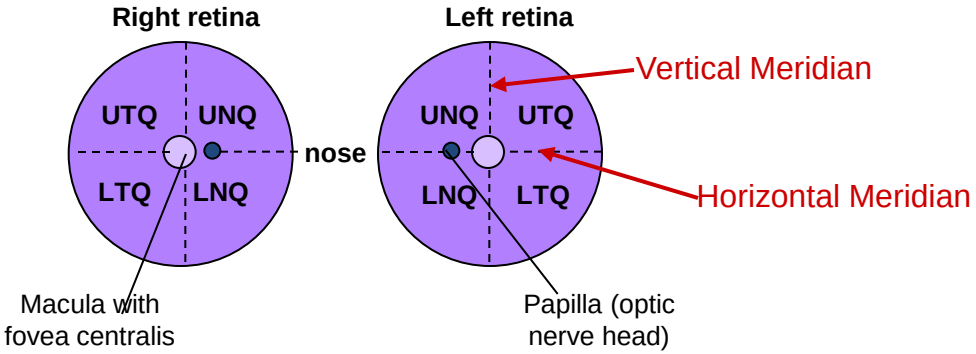
OT = Optic Tract
LGN = Lateral Geniculate Nucleus of Thalamus

Retinal Quadrants



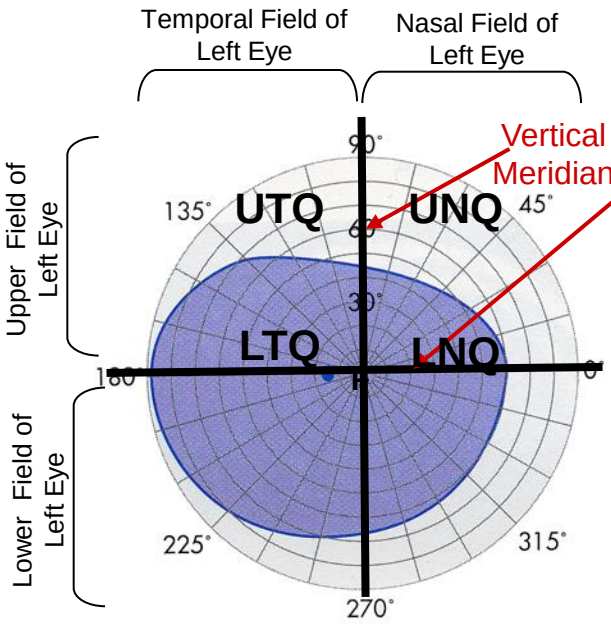
Retina as you would see it through the ophthalmoscope & the patient's pupil

Temporal Hemiretina	**Nasal Hemiretina**
UTQ = upper temporal quadrant	**UNQ = upper nasal quadrant**
LTQ = lower temporal quadrant	**LNQ = lower nasal quadrant**

The **blind spot** in the Visual Field corresponds to the location of the optic nerve head on the NASAL side of the retina.

Monocular Visual Fields

Definition: The entire area that can be "seen" by the patient without movement of the head and with the eyes fixed on a single spot.

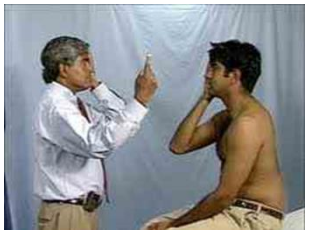


Normal **Monocular** Visual Field of **Left Eye**

Normal **Monocular** Visual Field of **Right Eye**

Mapping of Visual Fields:

- Confrontational method



- Perimetry (Manual or Automated)

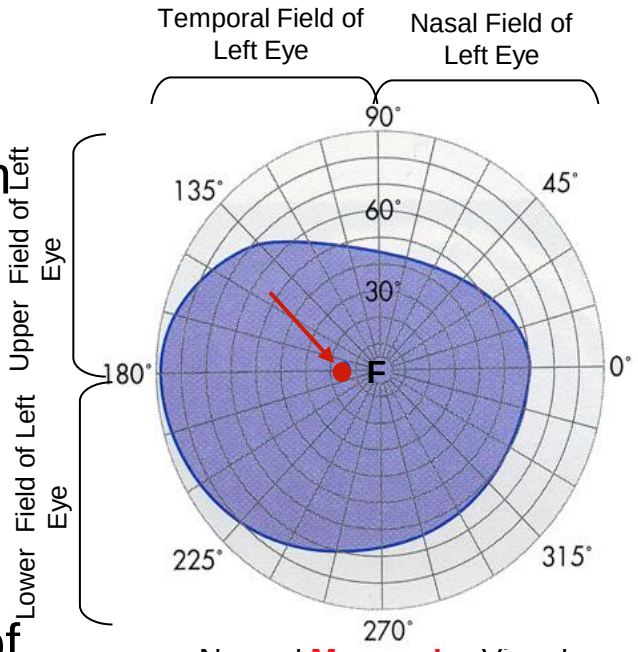
Monocular Visual Fields:

- Each eye is tested separately.
- The monocular visual field is plotted with the Fovea (F) at the center.
- The monocular visual field (colored area -- blue for left; green for right in this example) is not round.
- Horizontal and Vertical Meridians correspond to those of the retina and divide the visual field into upper temporal, upper nasal, lower temporal and lower nasal quadrants.

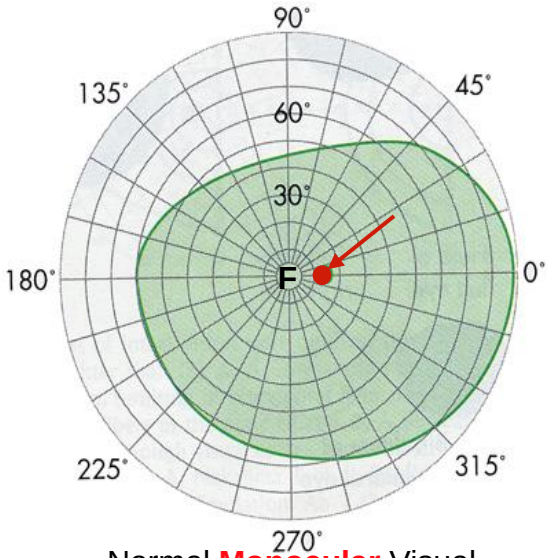
Monocular Visual Fields

Blind Spot

- 15° to the temporal side of the visual field of each eye
- On the horizontal meridian
- Corresponds to the location of the optic nerve head 15° to the nasal side of the retina of each eye.



Normal **Monocular** Visual Field of **Left Eye**



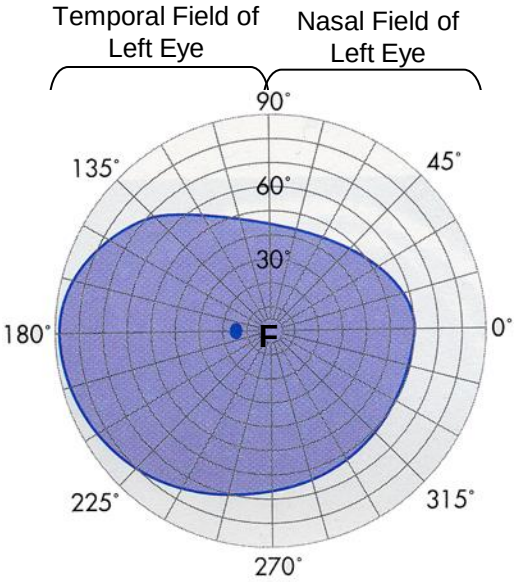
Normal **Monocular** Visual Field of **Right Eye**

Demonstration of the Blind Spot:

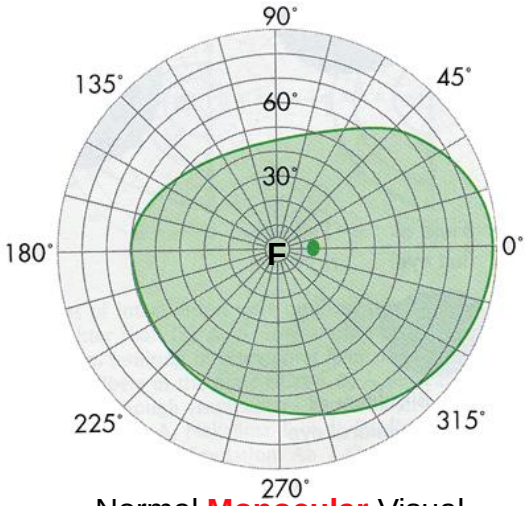
- Draw the star and box on a piece of paper.
- Close your left eye; Look at the **star** with your right eye; Move paper back and forth until the **green box** disappears.
- Open your left eye and the box can be seen because even though it was falling on the blind spot of the right eye, it is not falling on the blind spot of your left eye.
- With both eyes open & binocular vision intact, you don't realize that there is a blind spot since the corresponding spot on the contralateral retina will see the object.

Binocular Visual Fields

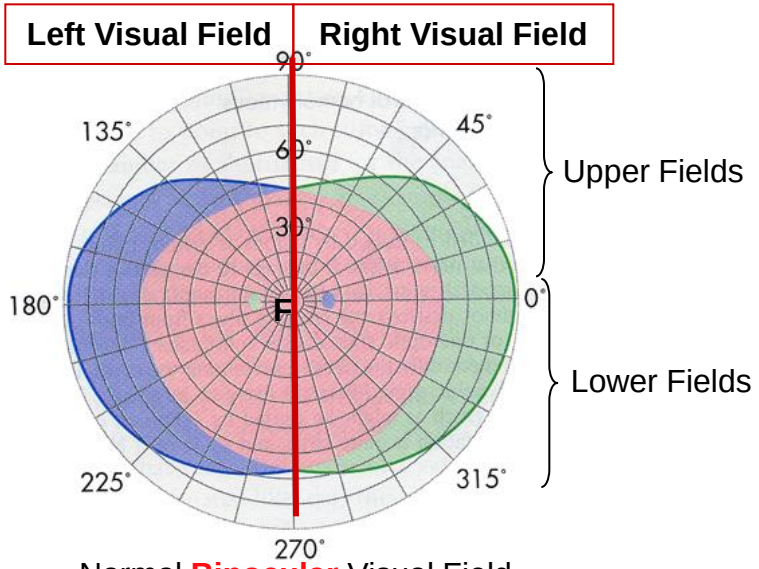
- Understand the difference between the "monocular visual field of the left eye" vs. the "Left Visual Field"
- and vice versa for the right counterparts.



Normal **Monocular** Visual Field of **Left Eye**



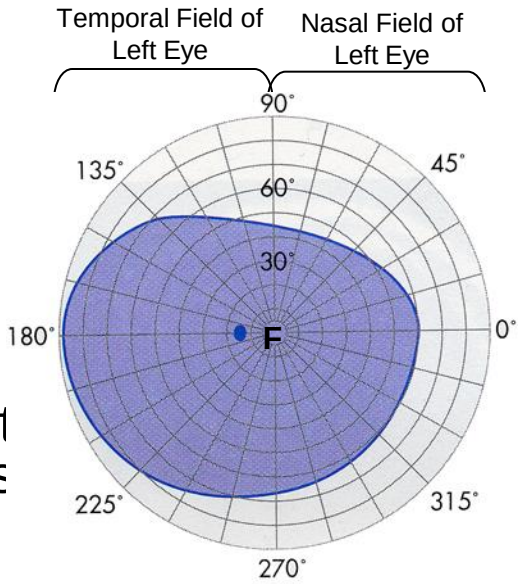
Normal **Monocular** Visual Field of **Right Eye**



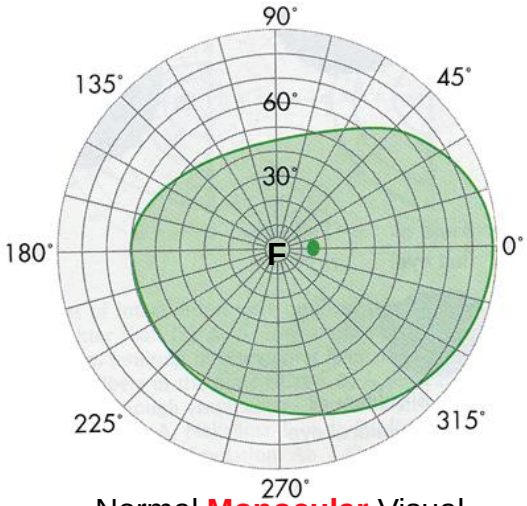
Normal **Binocular** Visual Field

Binocular Visual Fields

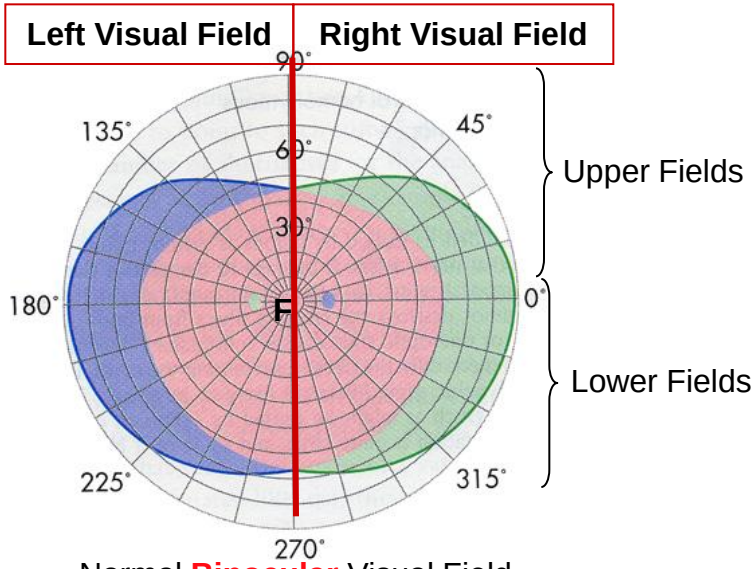
- Binocular vision is dependent upon the extraocular muscles aligning the eyes so that an image falls on "corresponding points" on the retina of each eye.
- This is essential for the brain to perceive a single image.
- Diplopia occurs when the images are not aligned to fall on corresponding points of each retina.



Normal **Monocular** Visual Field of **Left Eye**

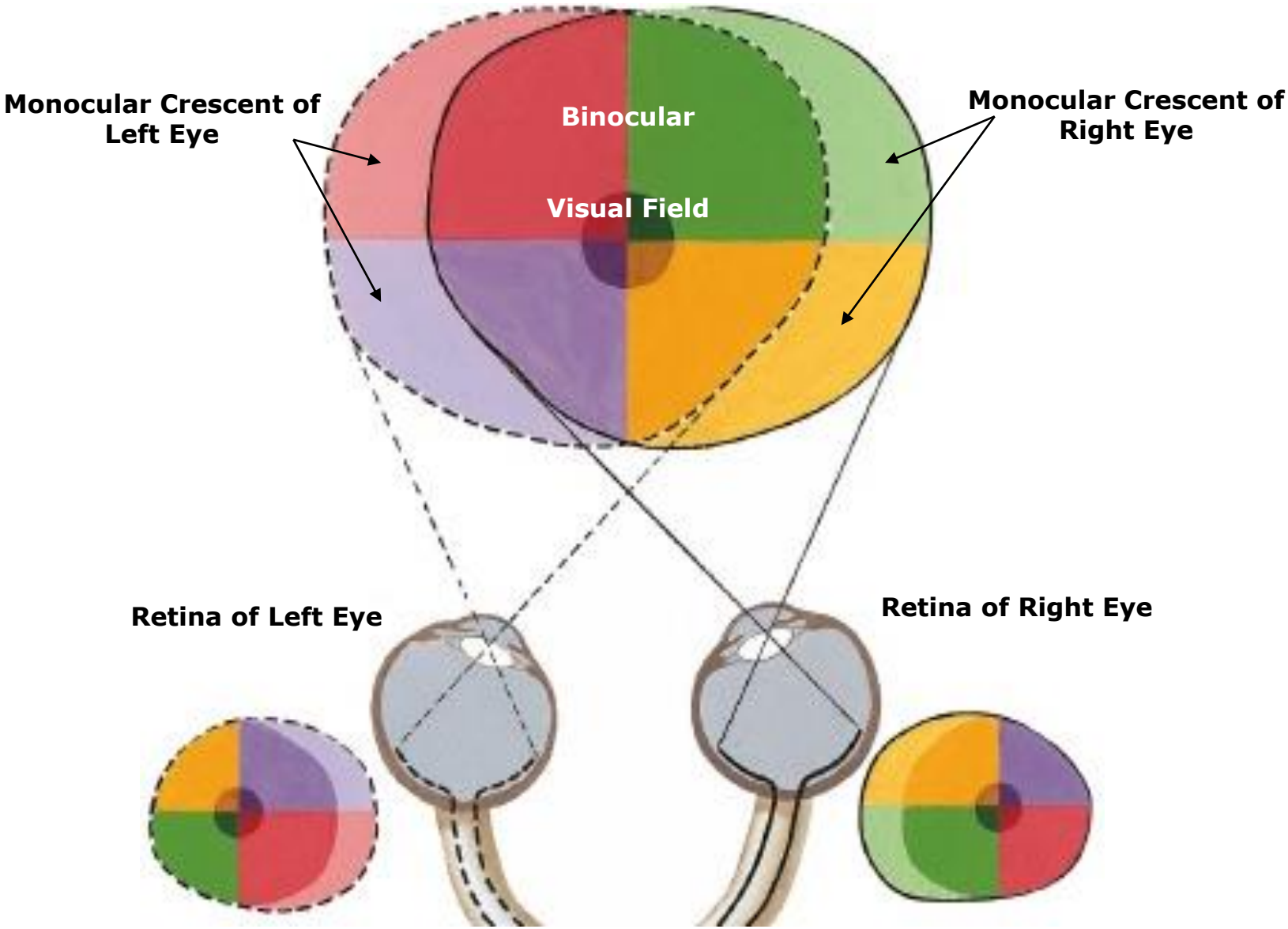


Normal **Monocular** Visual Field of **Right Eye**



Normal **Binocular** Visual Field

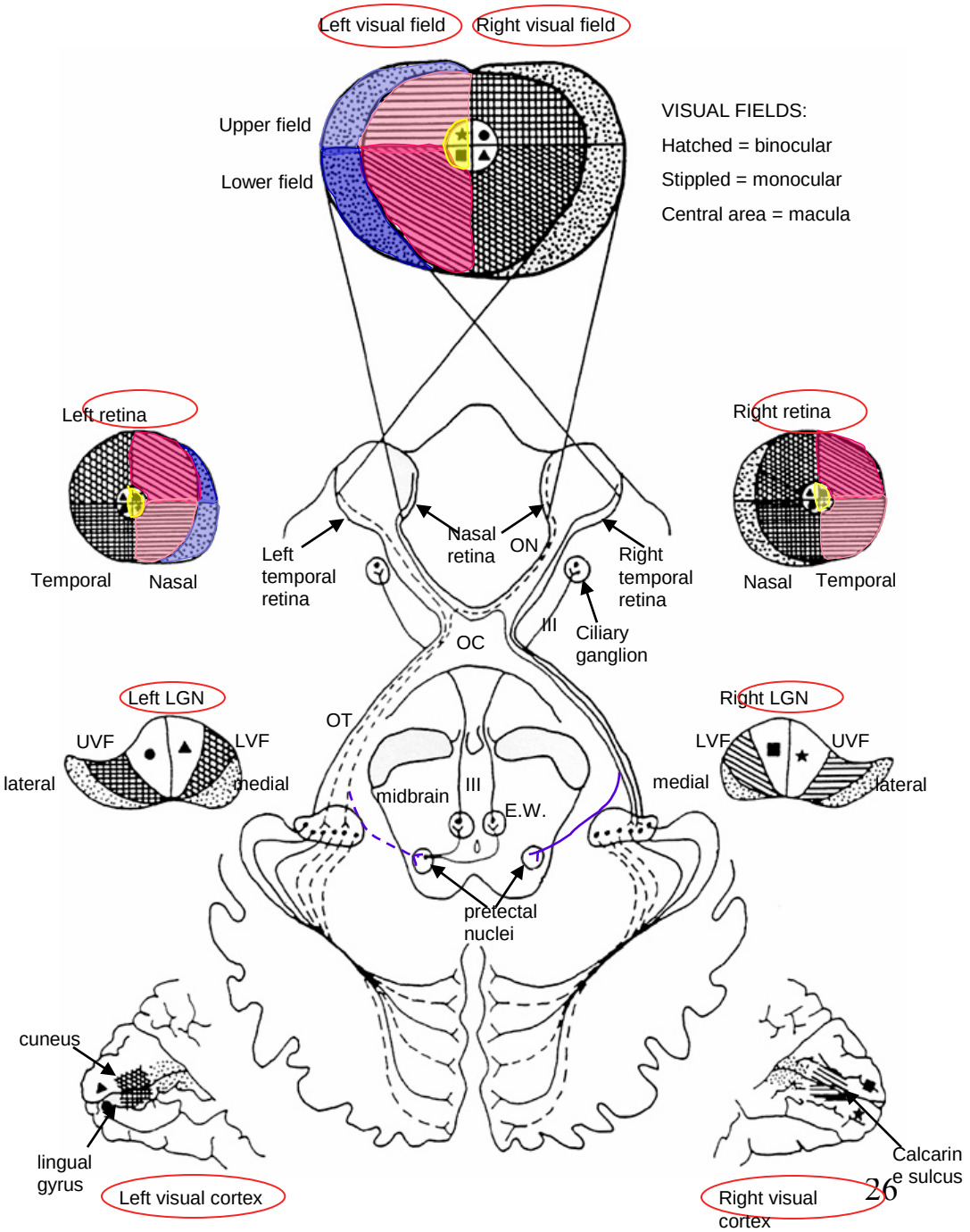
The Visual Pathway



Visual Pathway

- **Optic Nerve (ON)**
  - = Axons of ganglion cells in the retina of the corresponding eye
  - Outgrowth of diencephalon, so is a CNS tract & not a 'true' cranial nerve.
  - Myelinated by oligodendrocytes.
- **Optic Chiasm (OC)**
  - Located just anterior to pituitary
  - Partial crossing of optic nerve axons in the OC is essential to binocular vision
    - Axons from temporal fields cross
    - Axons from nasal fields do not cross
  - "Wilbrand's knee" may be artifact

Retinotopic representation
- **Central (macular) vision**
- **Peripheral vision**



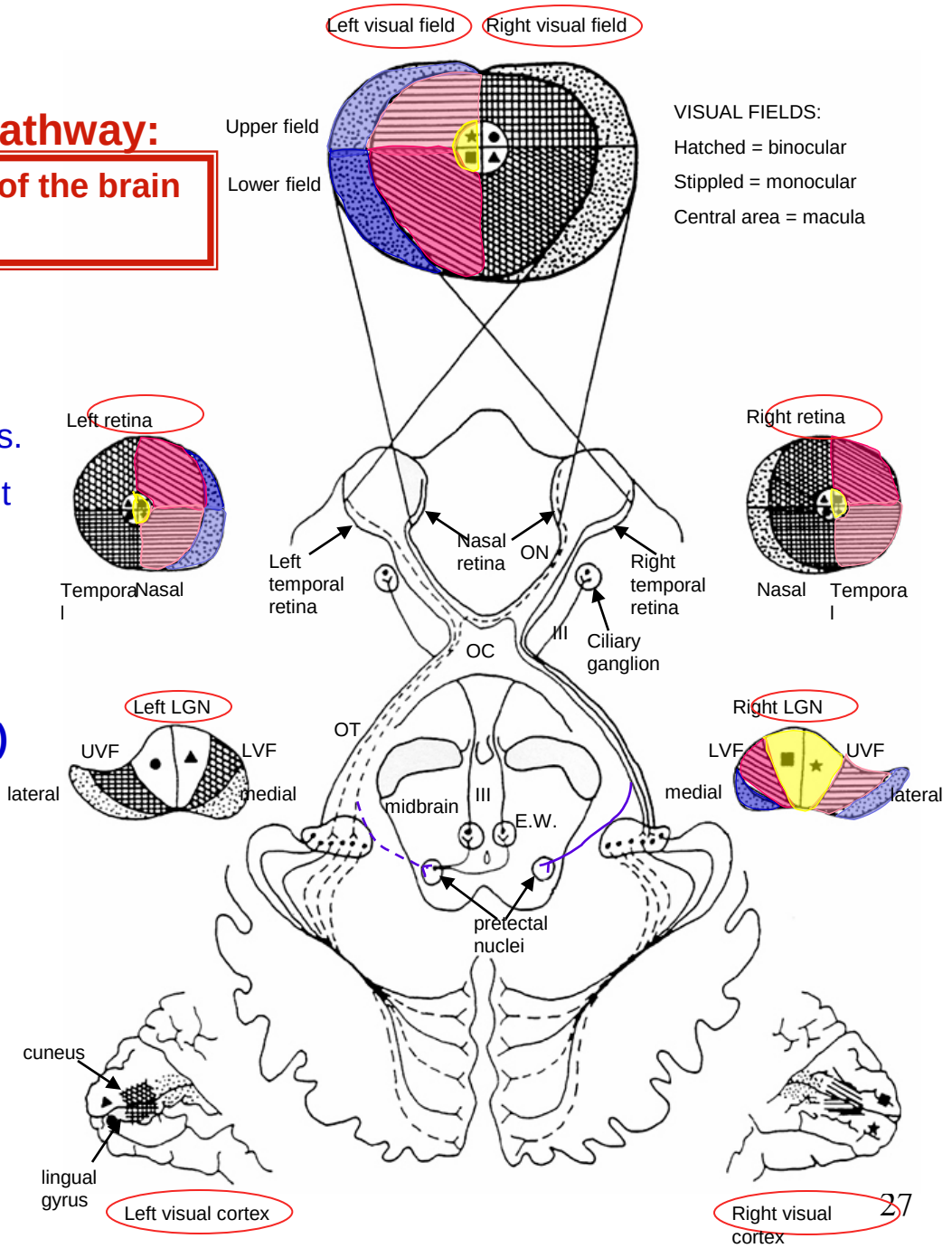
Visual Pathway

Post-Chiasmatic portion of the pathway:

From optic tract to visual cortex, each side of the brain deals with the contralateral visual field.

- **Optic Tract (OT)**
  - Optic nerve fibers from the optic chiasm continue as the optic tract & terminate in the lateral geniculate nucleus of thalamus.
  - Each tract contains axons that carry input from the contralateral visual field.
    - Left OT receives from R. visual field
    - Right OT receives from the L. visual field
- **Lateral Geniculate Nucleus (LGN)**
  - Primary termination of OT fibers
  - Each LGN receives input from the contralateral visual field.
  - OT Projections to pretectum for reflexes

Retinotopic representation
- **Central (macular) vision**
- **Peripheral vision**

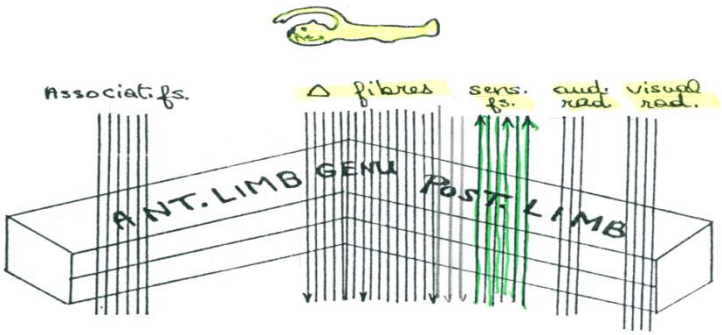


Visual Pathway

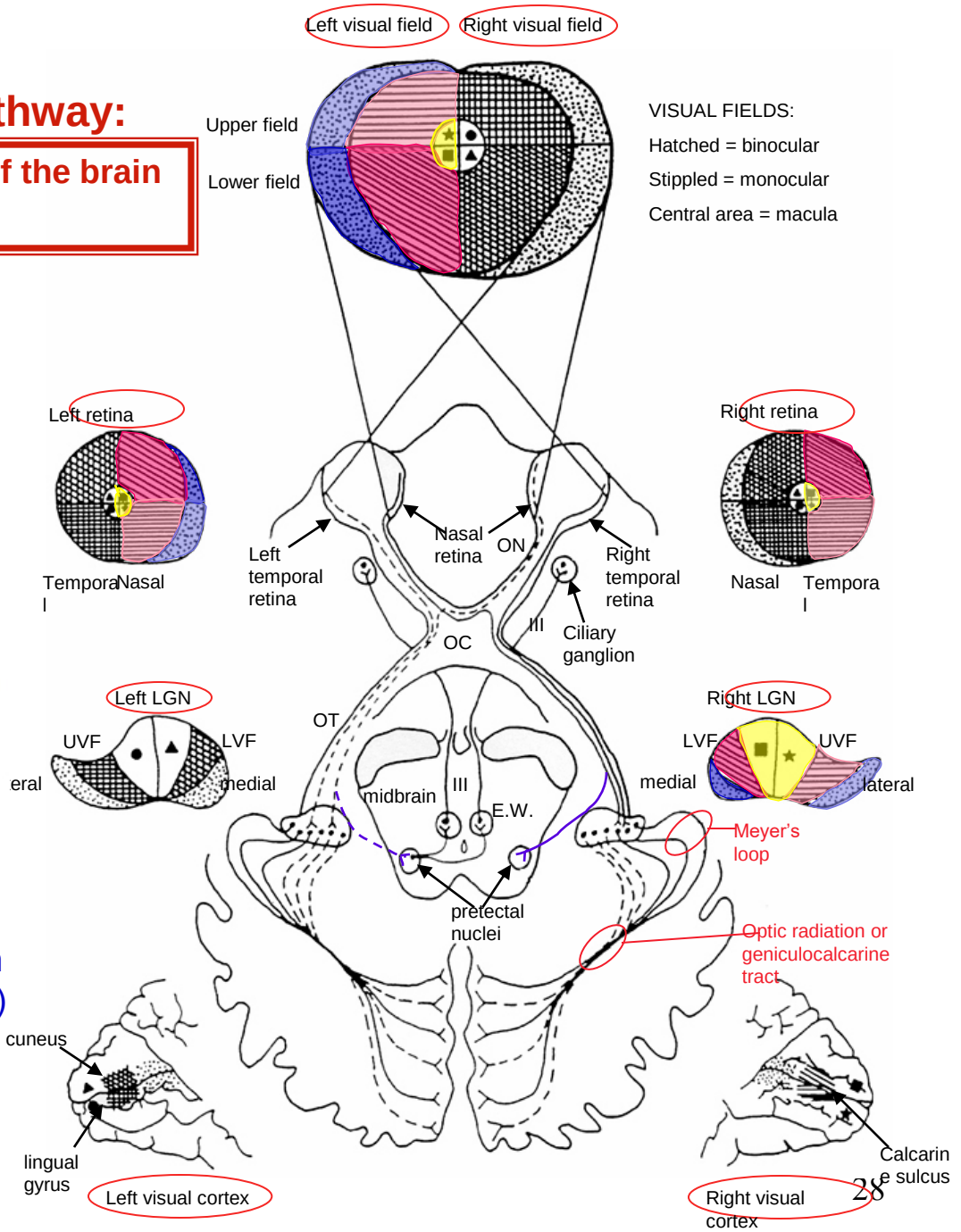
Post-Chiasmatic portion of the pathway:

From optic tract to visual cortex, each side of the brain deals with the contralateral visual field.

- **Geniculocalcarine Tract (= optic radiations)**
  - Axons of LGN neurons travel to primary visual cortex (Area 17) via the geniculocalcarine tract located in the retrolenticular and sublenticular portions of the internal capsule.



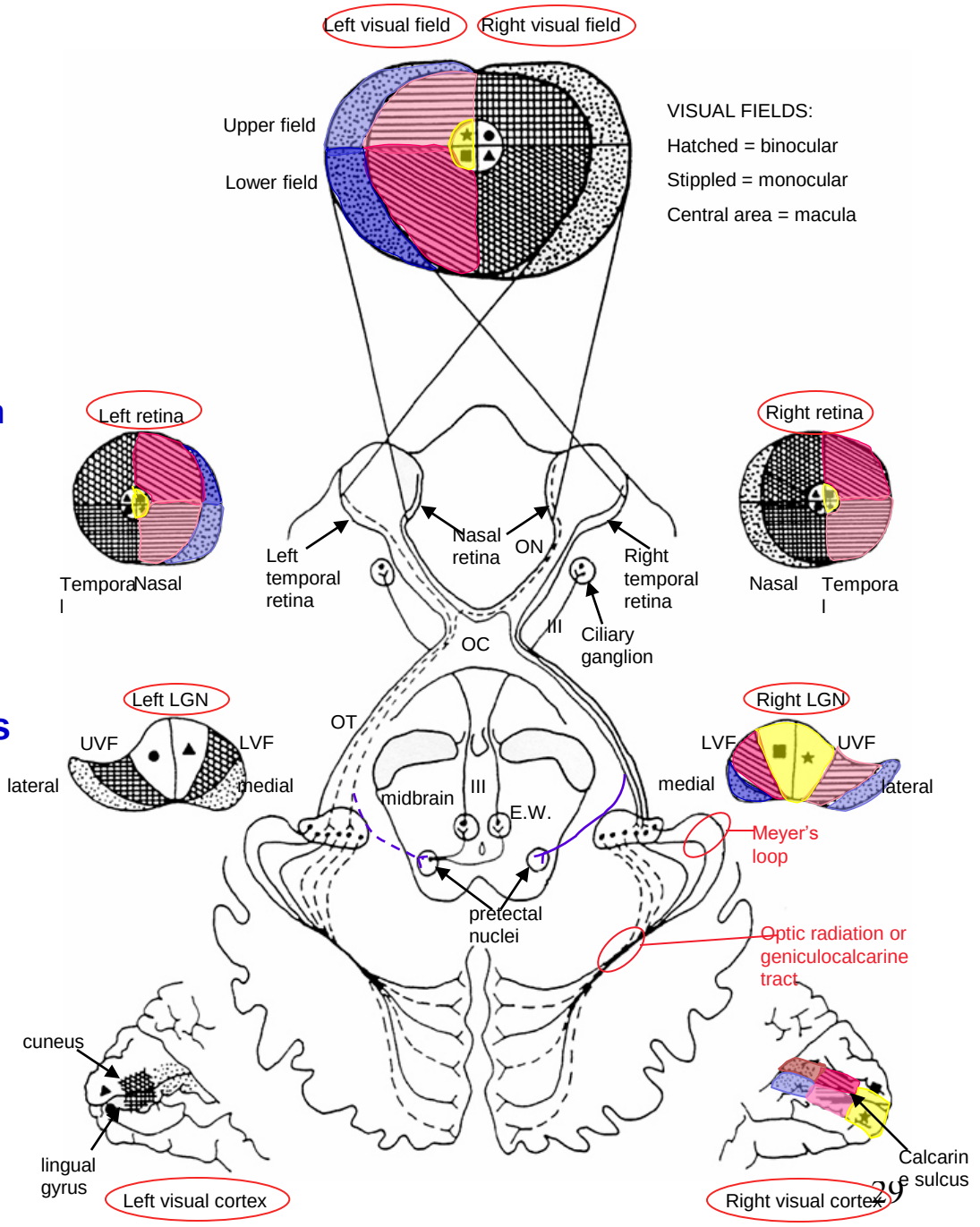
  - Axons from upper visual fields take a looping course into the temporal lobe on the way to visual cortex. (=Meyer's loop)
  - Axons from lower visual fields take a more direct route to visual cortex.
  - Macular fibers are in an intermediate location in the optic radiation.



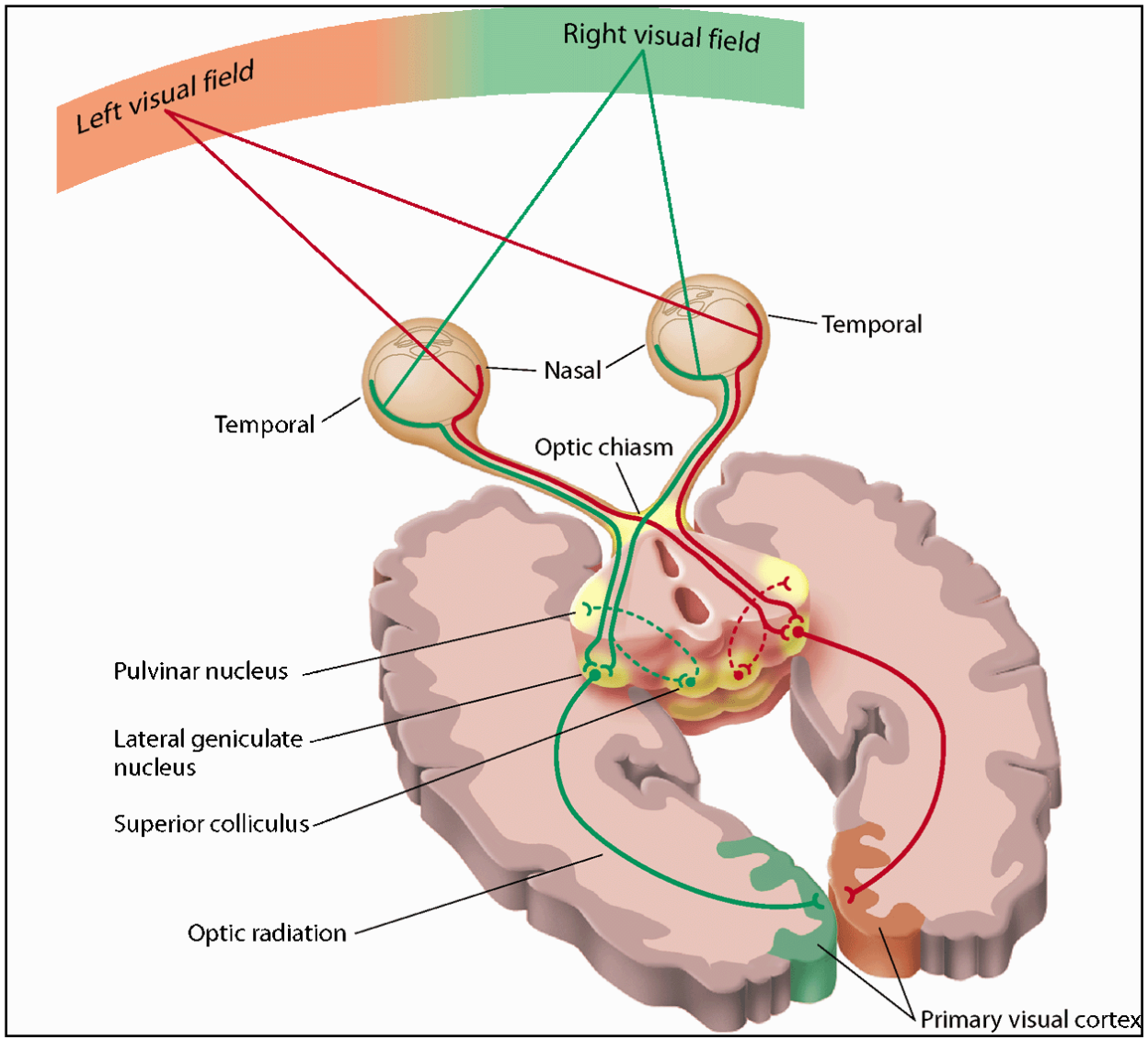
Visual Pathway

- **Primary Visual Cortex (Area 17)**
  - Located on either side of & within the calcarine fissure.
  - Upper fields project to the lingual gyrus.
  - Lower fields project to the cuneus.
  - Macular representation is most caudal in Area 17.
  - Peripheral field representation is in the rostral 2/3^{rds} of Area 17.
  - Lesions of Area 17 result in blindness in the contralateral visual field.
- **Association Visual Cortex (Areas 18 & 19)**
  - Input from Area 17 & elsewhere
  - Deals with complex aspects of vision
  - Lesions of result in visual agnosia.

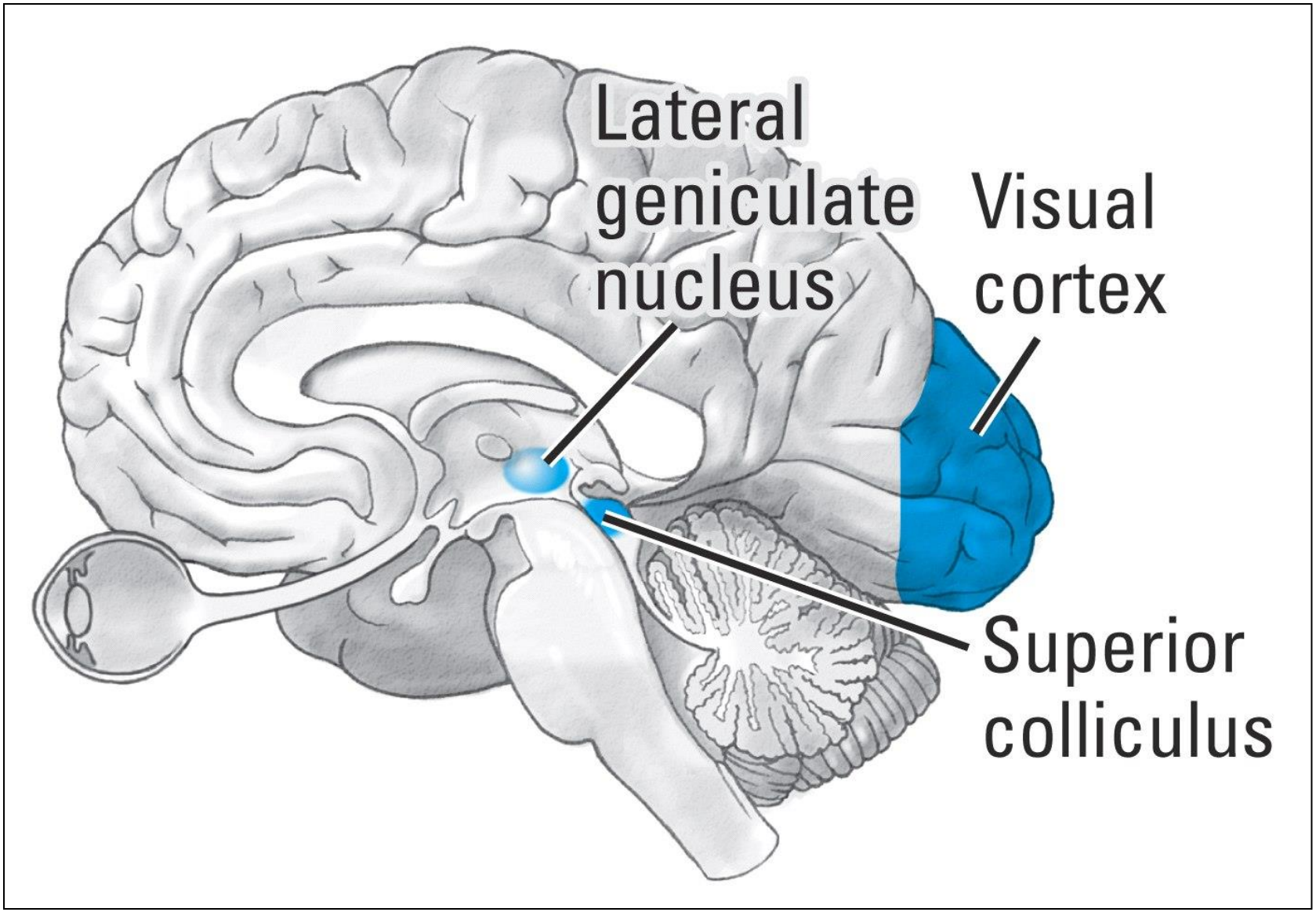
Retinotopic representation
- **Central (macular) vision**
- **Peripheral vision**



Form Eye to the CNS

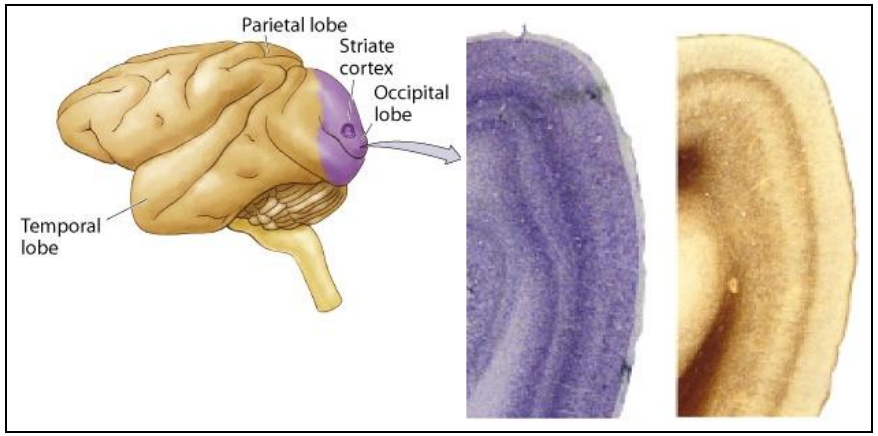


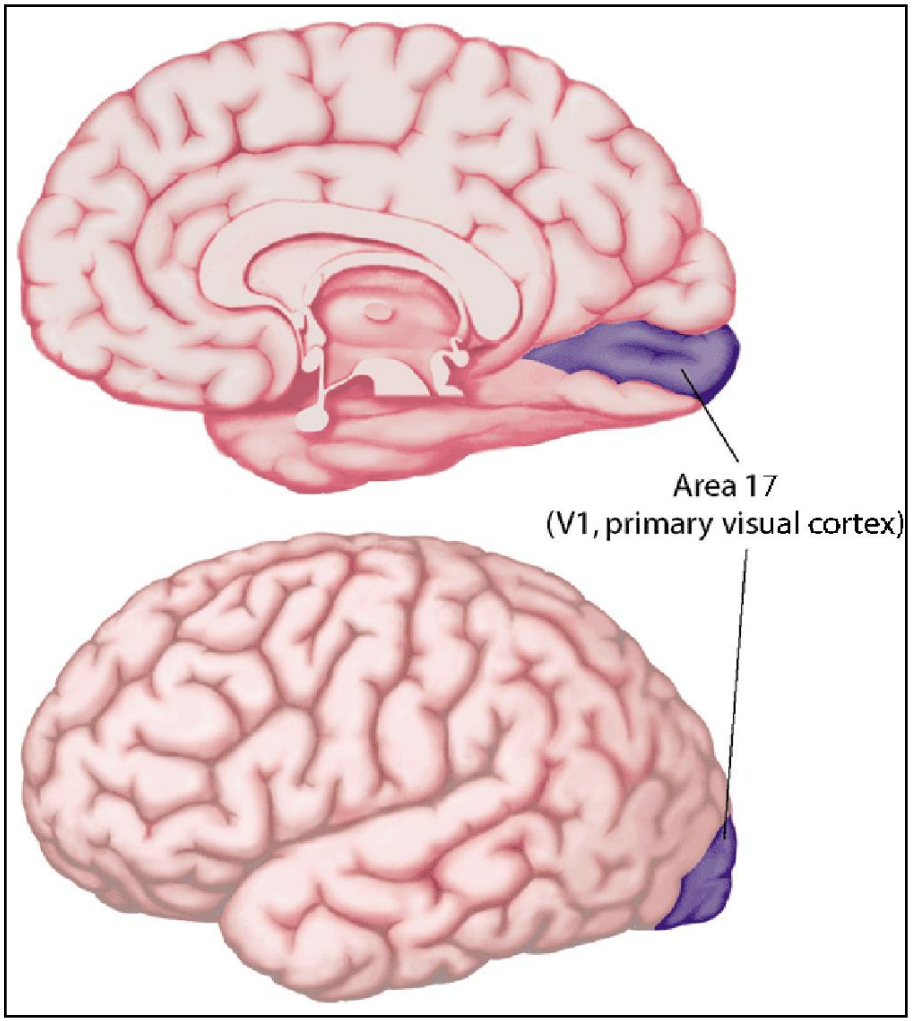
Form Eye to the CNS



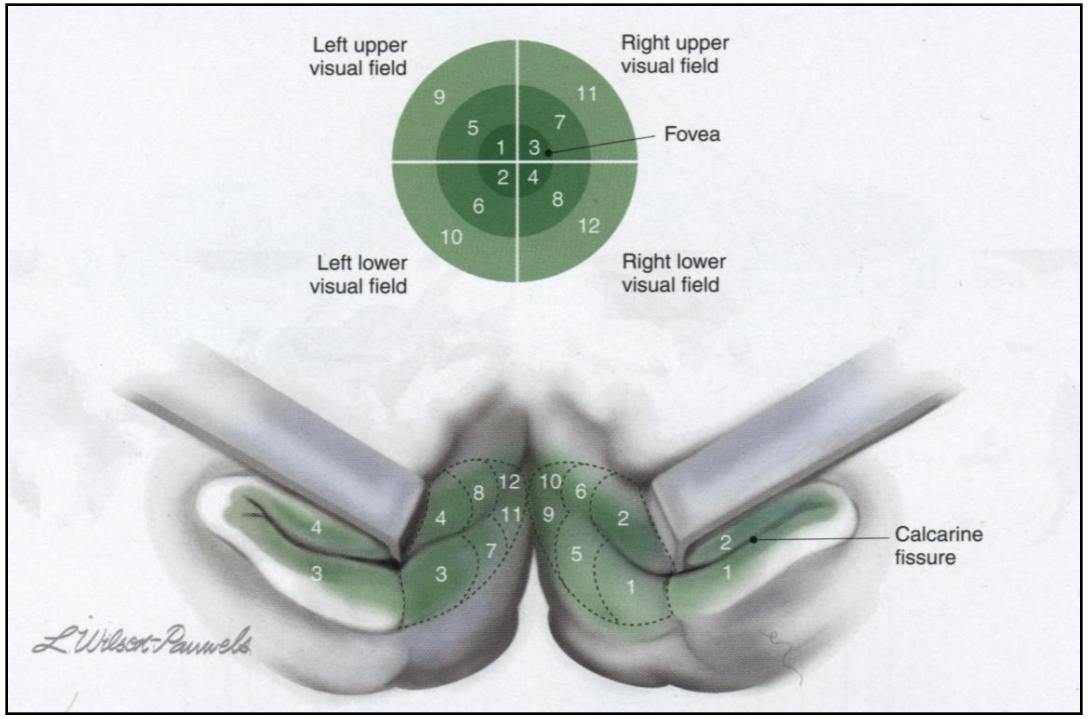
Visual Cortex – Primary Visual Cortex

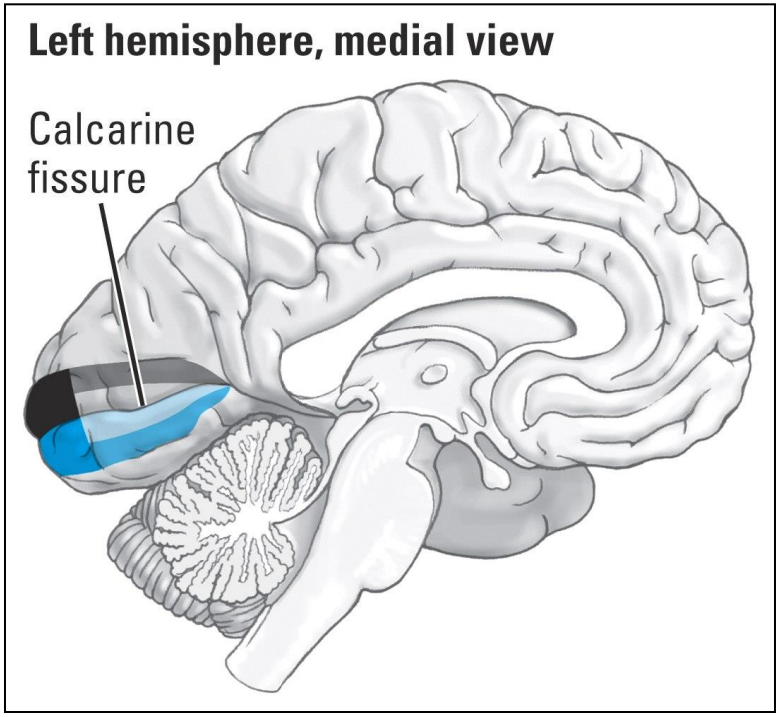
- Different names for primary visual cortex:
- Brodmann's area 17
- V1
- primary visual cortex
- striate cortex ("striped" cortex)



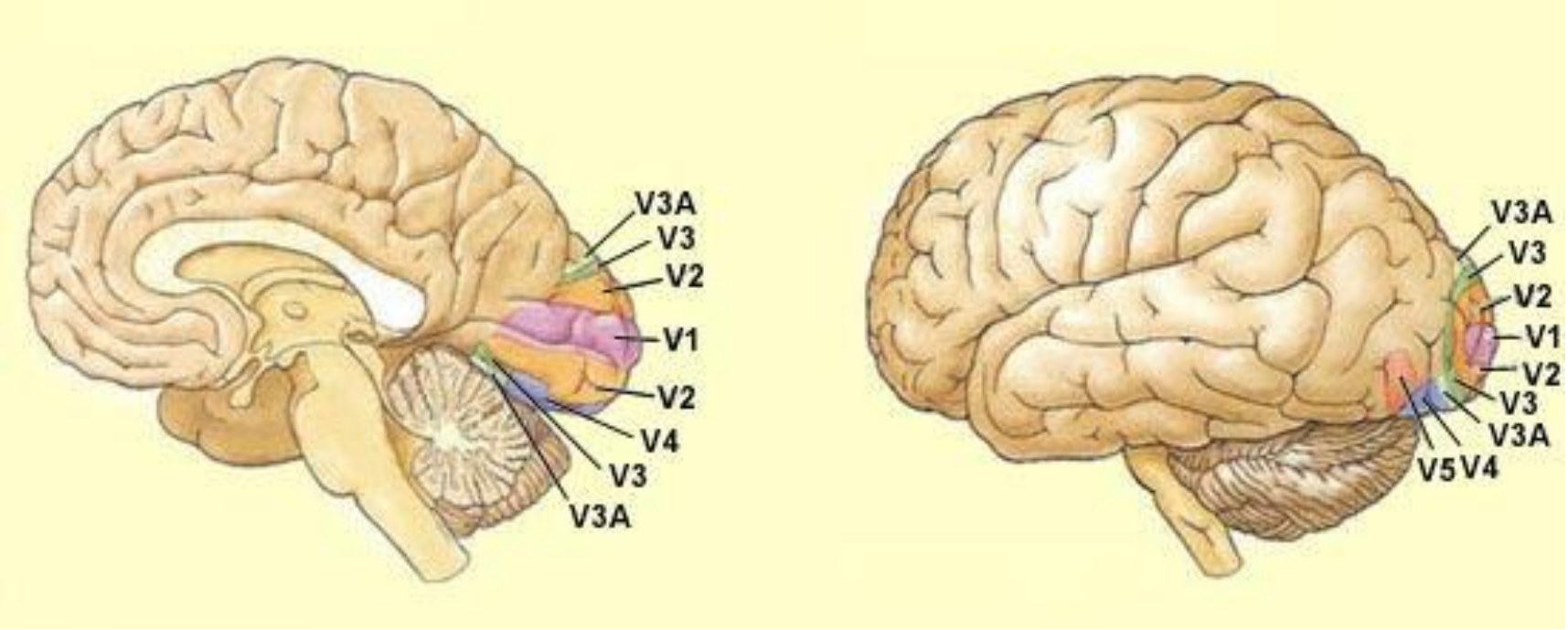


Retinal Topography



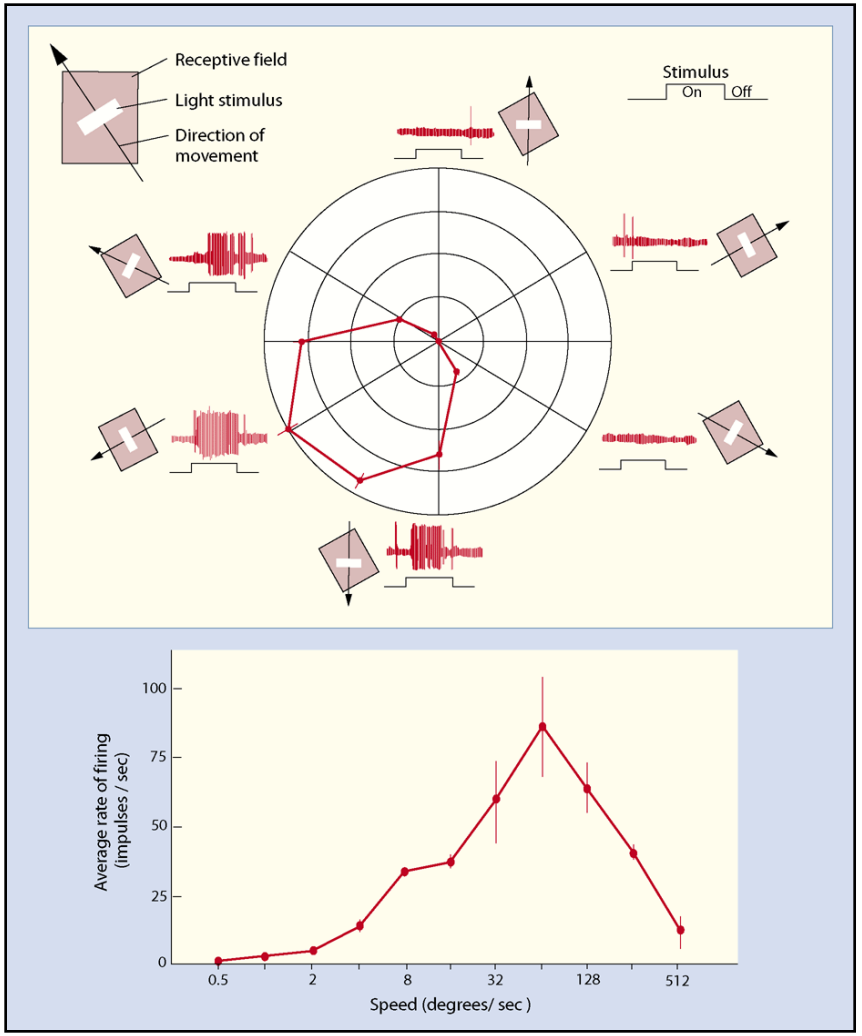


Visual Cortex

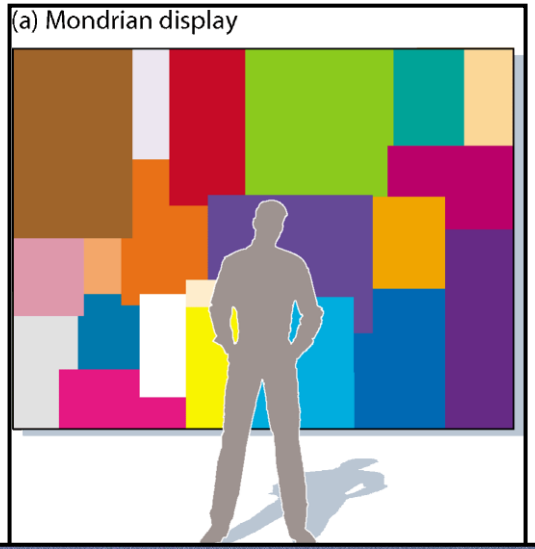


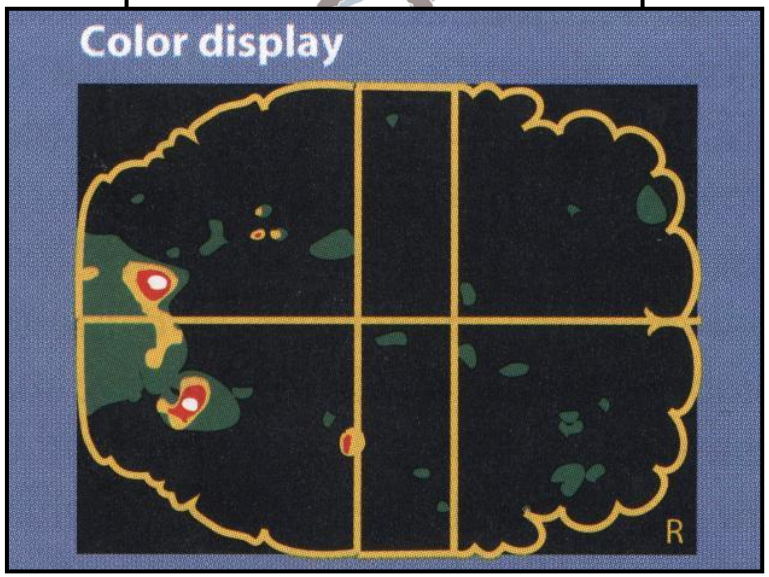
Visual Cortex: Area MT or V5 MOTION

- Cells in area MT or V5 respond to movement but not color
- For example, this particular neuron in this monkey's V5 area responds best when stimulus moved down and to the left

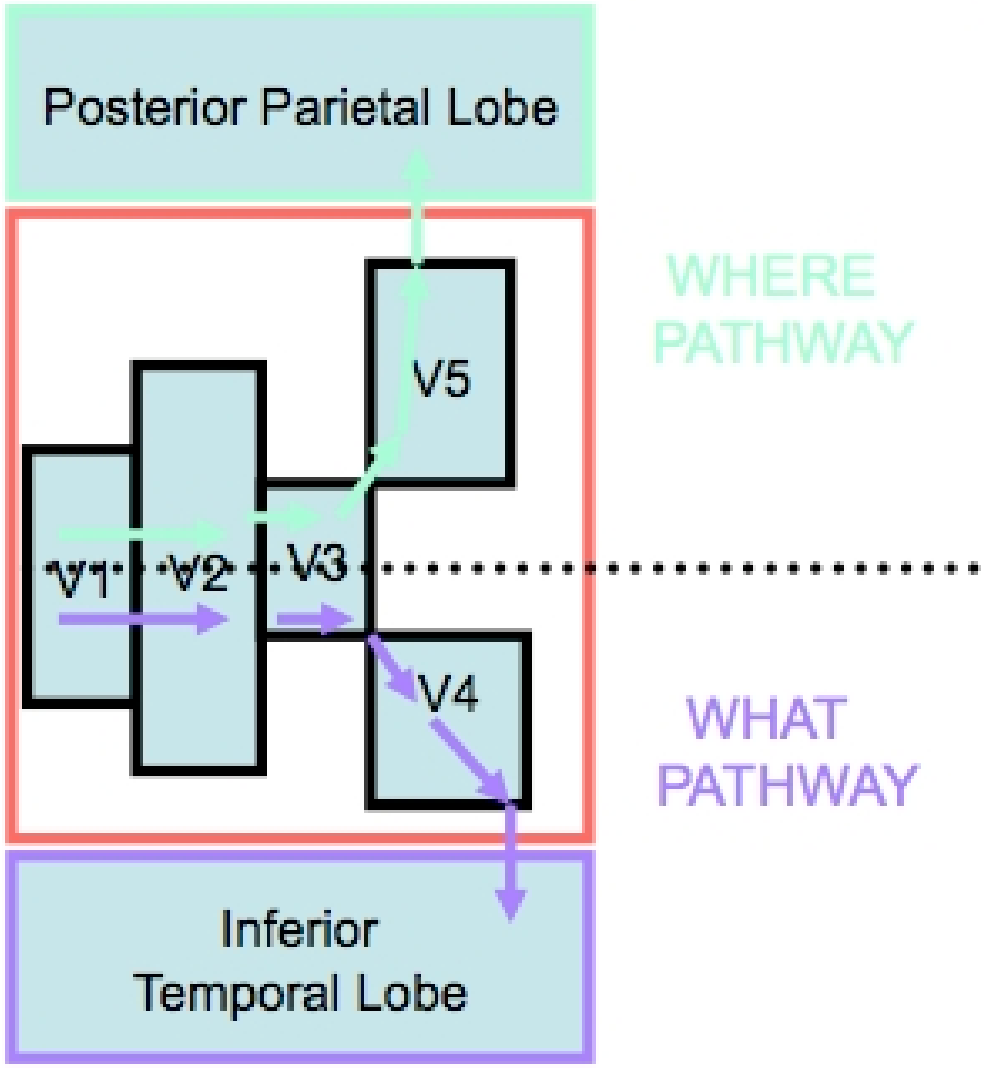


Visual Cortex:Area V4
COLOUR





Visual Cortex



Areas of Occipital Cortex

VI – segregates pattern visior from motion signals

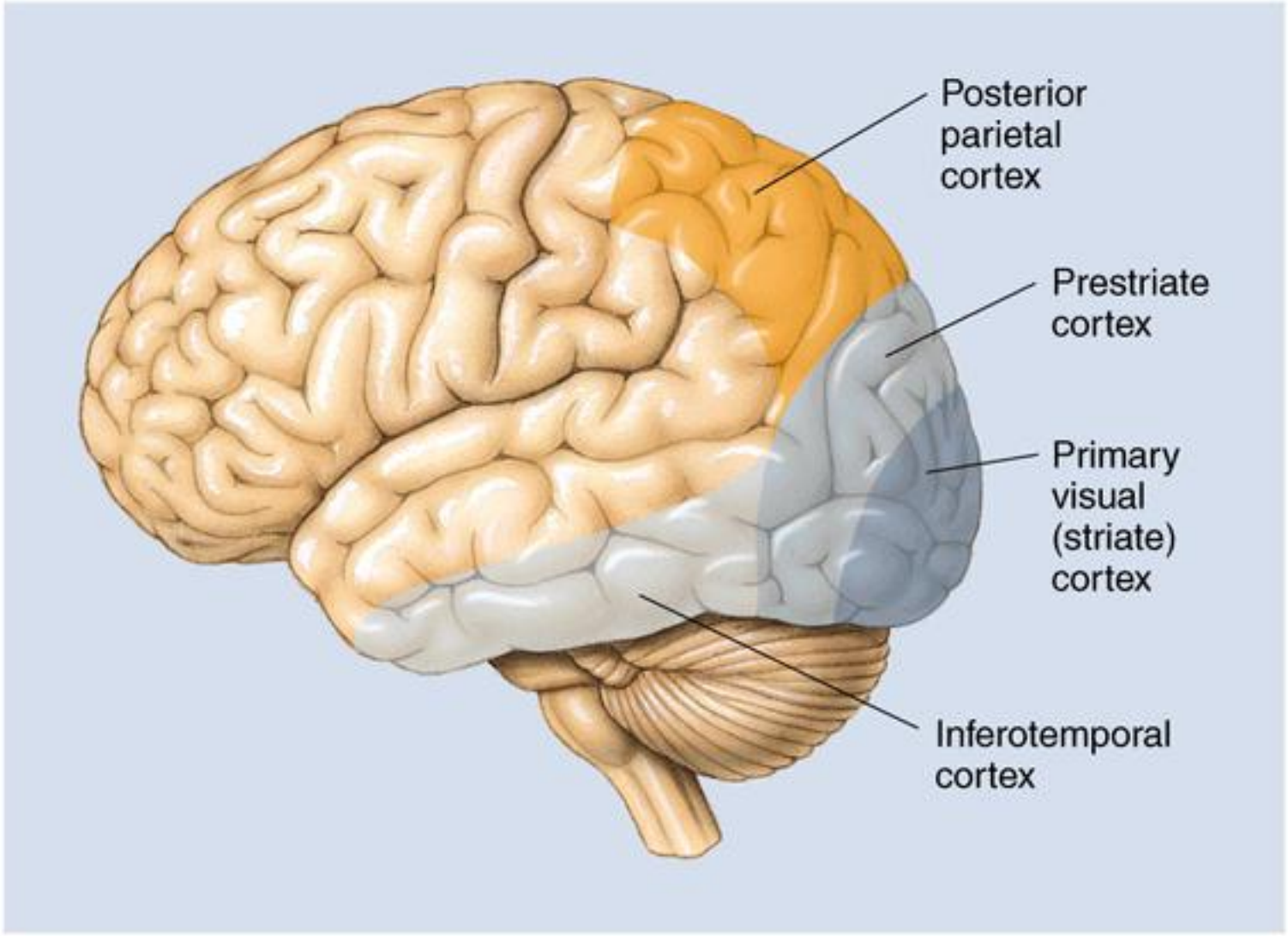
V2 – 3D vision/ seeing camouflage/ more complex patterns

V3 – shape perception

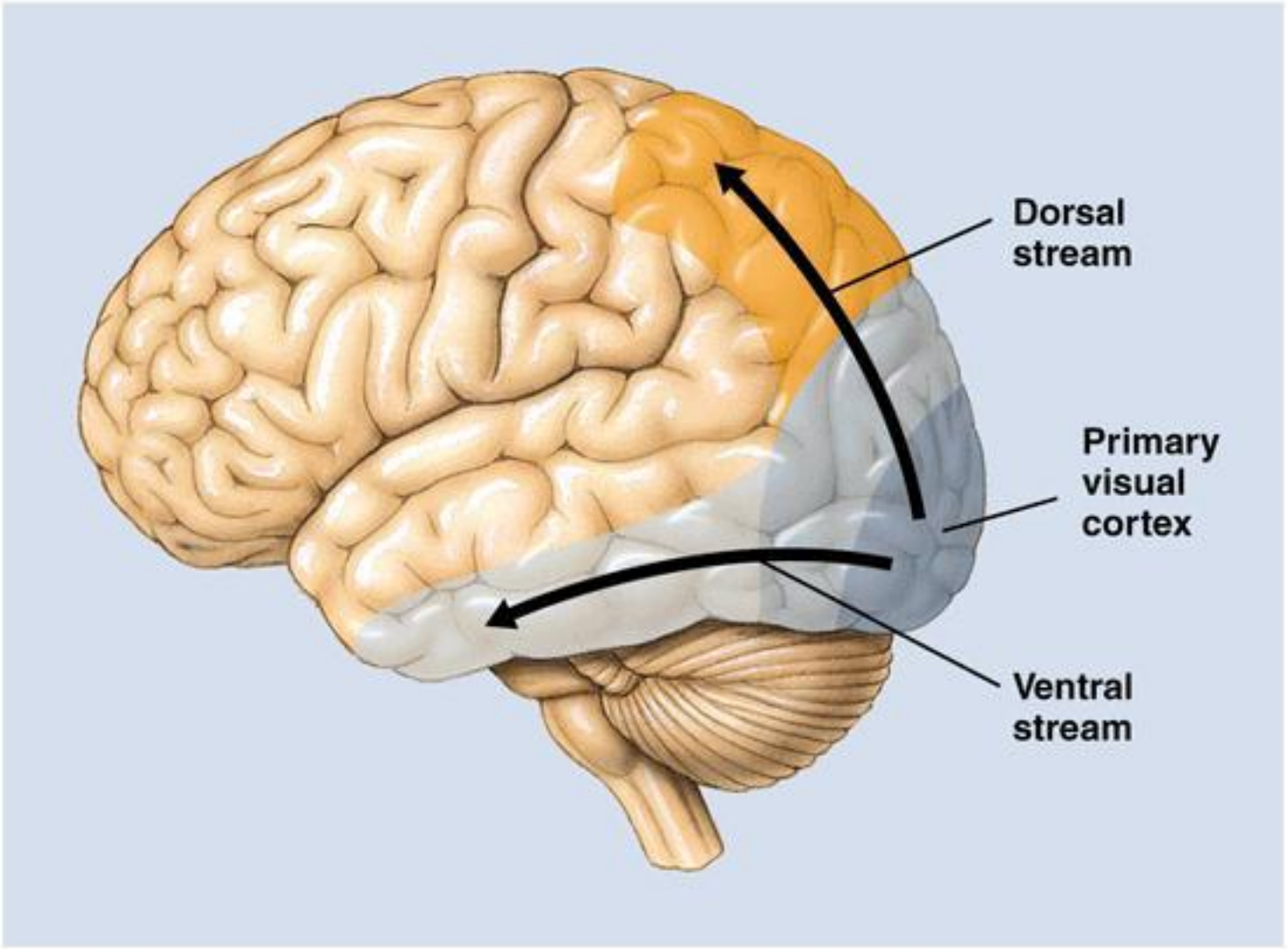
V4 – colour area and shape perception

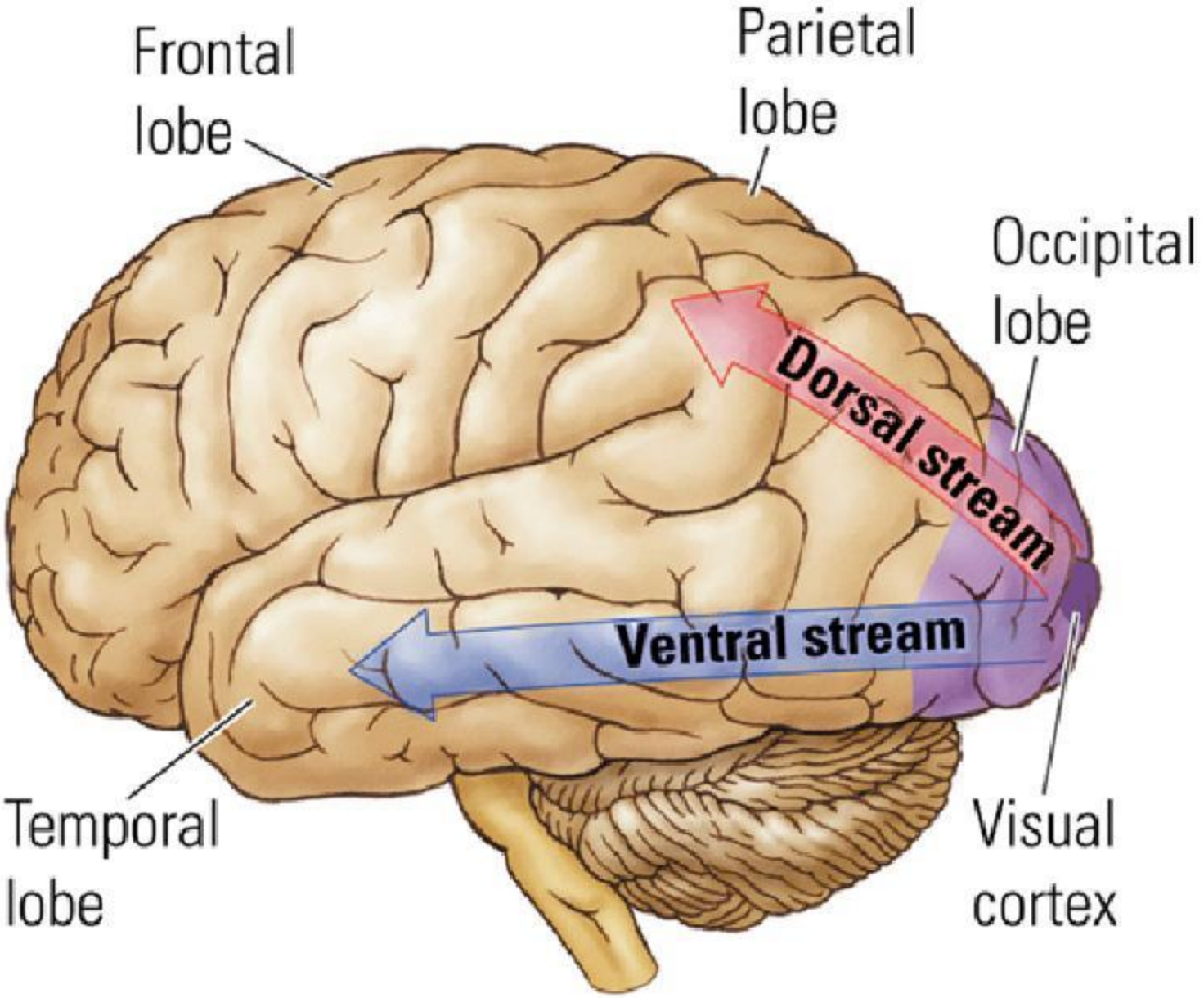
V5 – motion area

► Visual Areas of the Human Cerebral Cortex

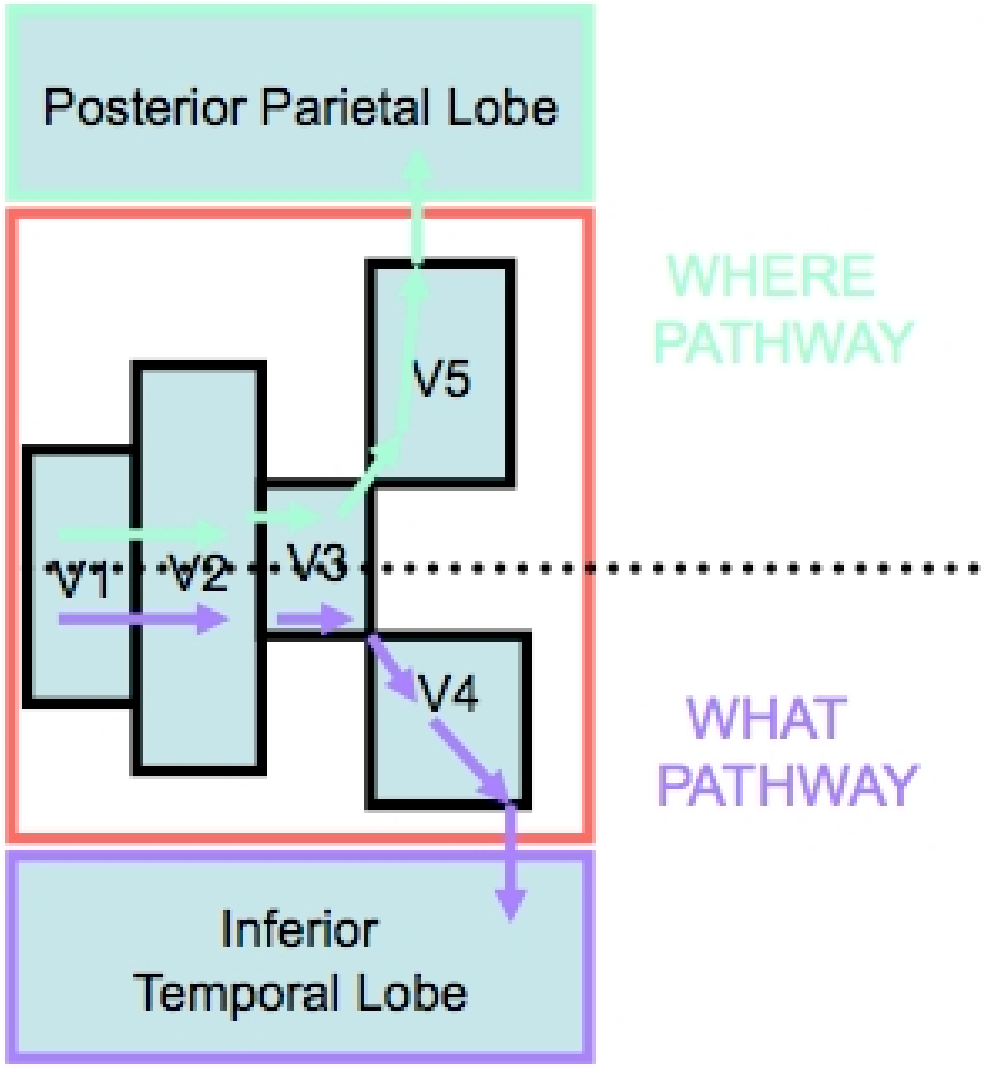


► Visual Information Pathways




Frontal lobe
Parietal lobe
Occipital lobe
Dorsal stream
Ventral stream
Temporal lobe
Visual cortex

Visual Cortex



Areas of Occipital Cortex

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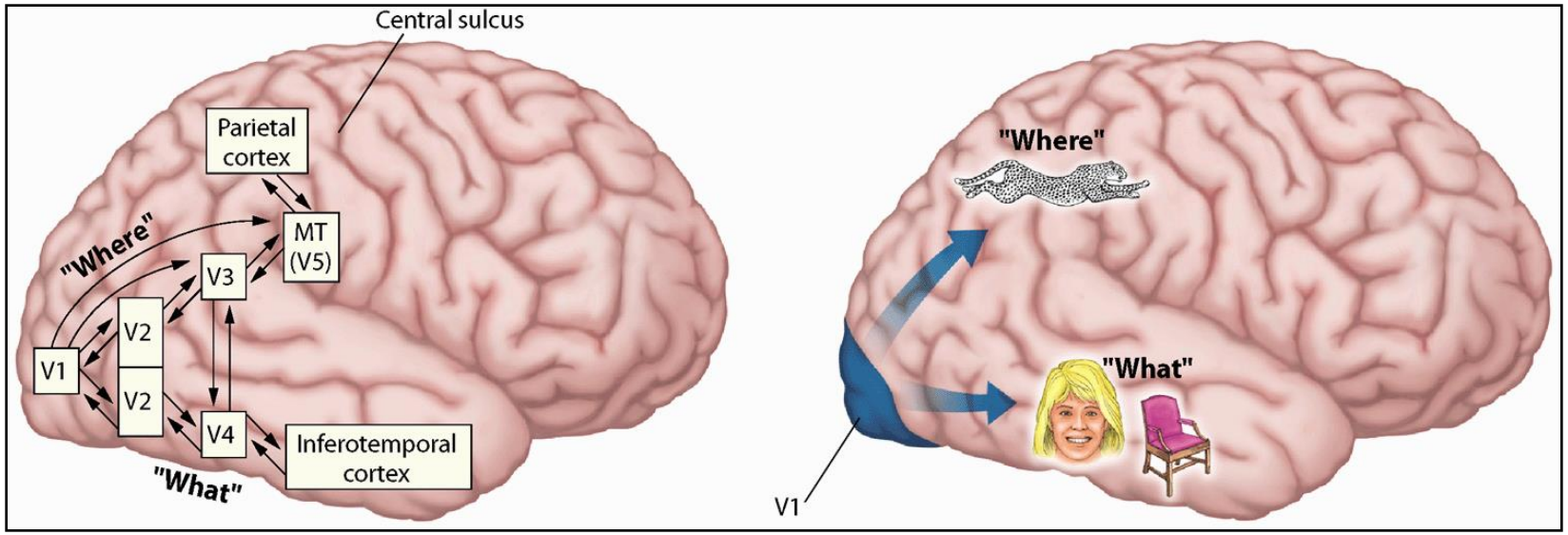
V5 – motion area

Two General Projections From the Primary Visual Cortex

- Dorsal stream – Occipito-parietal stream spatial perception – action- “where” or “how to”
- Ventral stream – Occipito-temporal stream object perception – identification – “what” stream



Agenda

- **Anatomy of visual pathway**
- **Visual pathway disorders**
- **Quiz**

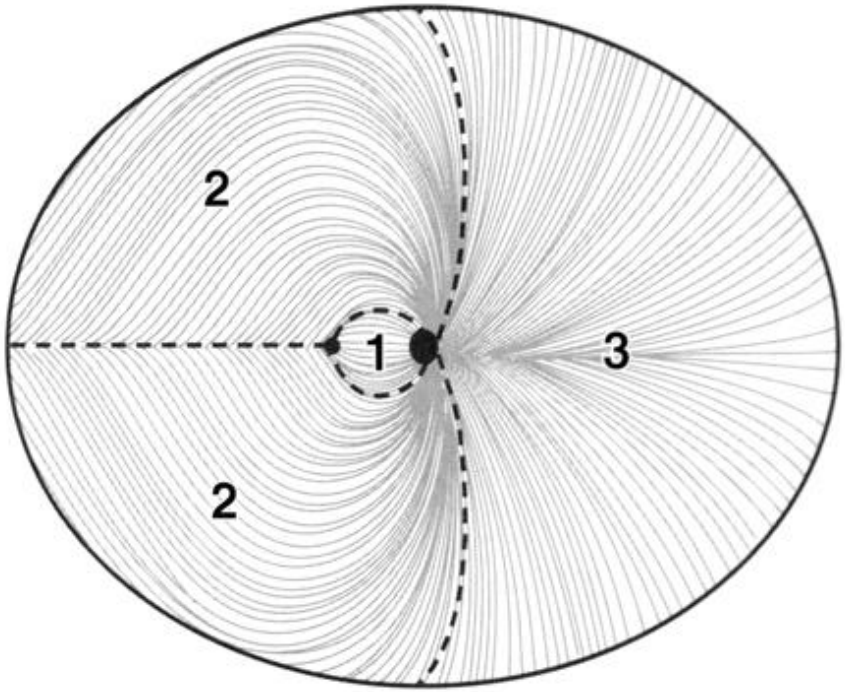
Agenda

- Anatomy of visual pathway
- Visual pathway disorders
- Quiz

Optic nerve-type field defects

- Retinal fibers enter optic discs in a specific manner.
- **Nerve fiber bundle (NFB) defects are of the following:**

1. Papillomacular bundle.
2. Sup. & Inf. Arcuate bundle.
3. Nasal bundle.

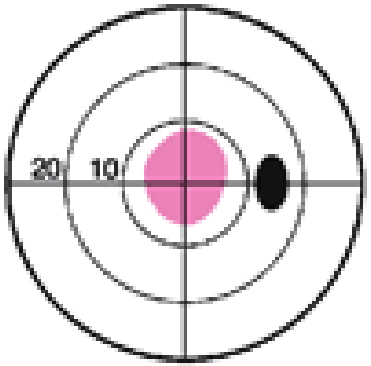


Papillomacular Bundle

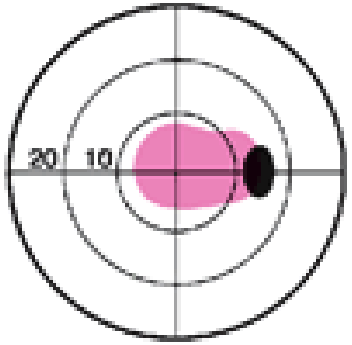
- Macular fibers that enter the temporal aspect of the disc.
- *Defect, result in the following:*

1. ***Central scotoma:*** defect covering central fixation.
2. ***Centrocecal scotoma:*** a central scotoma conneted to the blind spot.
3. ***Paracentral scotoma***: defect of some of the fibers of the papillomacular bundle lying next to, but not involving central fixation.

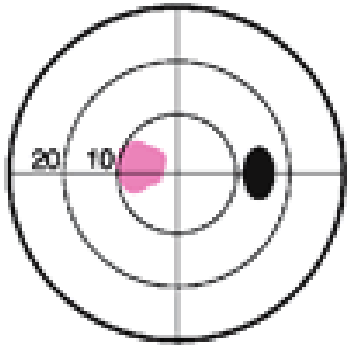
Papillomacular bundle-defects



A *central scotoma* involves the point of central fixation. It's always associated with decreased visual acuity.



A *centrocecal scotoma* involves the point of central fixation and the area between the blind spot and the fixation point.

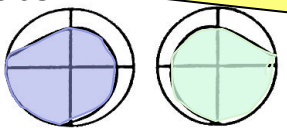


A *paracentral scotoma* affects an area of the visual field that is nasal or temporal to the point of central fixation.

Lesions of the Visual Pathway

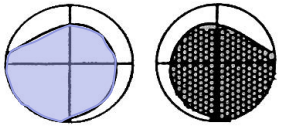
1. Normal visual fields

Left Right

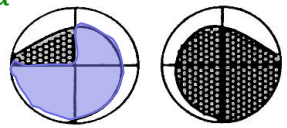


Fields, not retinal quadrants

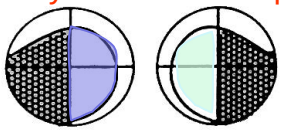
2. Blindness of the right eye



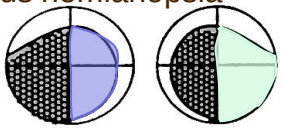
3. Blindness of right eye + contralateral left upper quadrantanopia



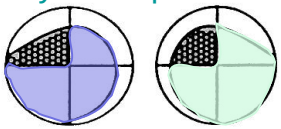
4. Bitemporal heteronymous hemianopsia



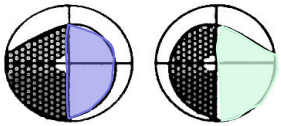
5. Left homonymous hemianopsia



6. Left upper homonymous quadrantanopsia



7. Left homonymous hemianopsia with macular sparing



Masked area = area of visual loss

Definitions

- ✓Strabismus
- ✓Diplopia
- ✓Amblyopia
- ✓Scotoma
- ✓Quadrantanopsia - # 3, 6
- ✓Hemianopsia - # 4, 5, 7

Aka "field cuts"

- ✓Heteronymous Defects - # 3, 4
- ✓Homonymous Defects - # 5, 6, 7
- ✓Congruous Defects - # 5, 6, 7
- ✓Incongruous Defects - # 3
- ✓Altitudinal Defects - # 6

Lesions of the Visual Pathway

Left Right

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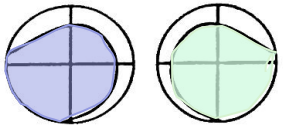

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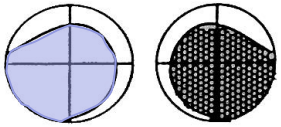

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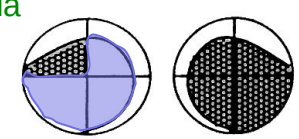
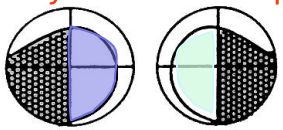


4. Bitemporal heteronymous hemianopsia



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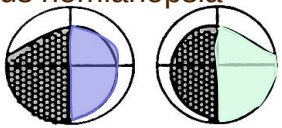

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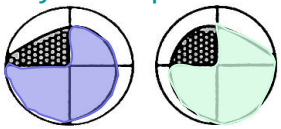

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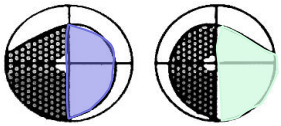
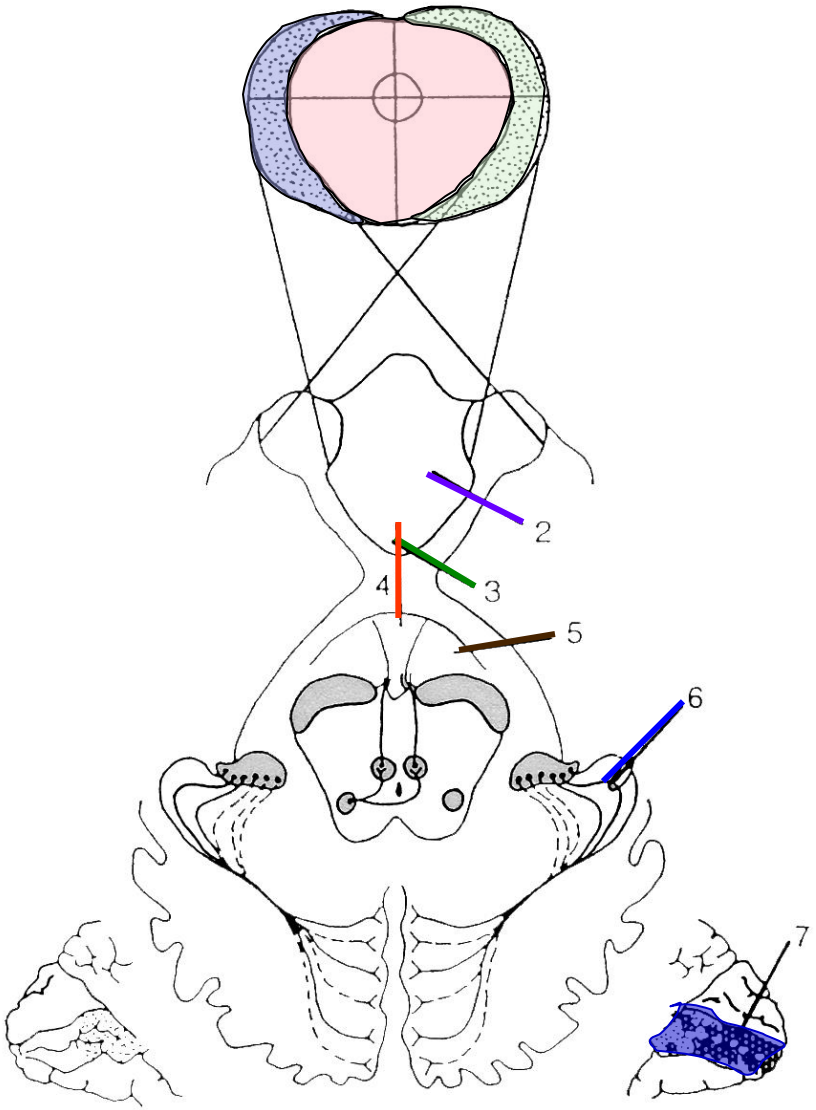
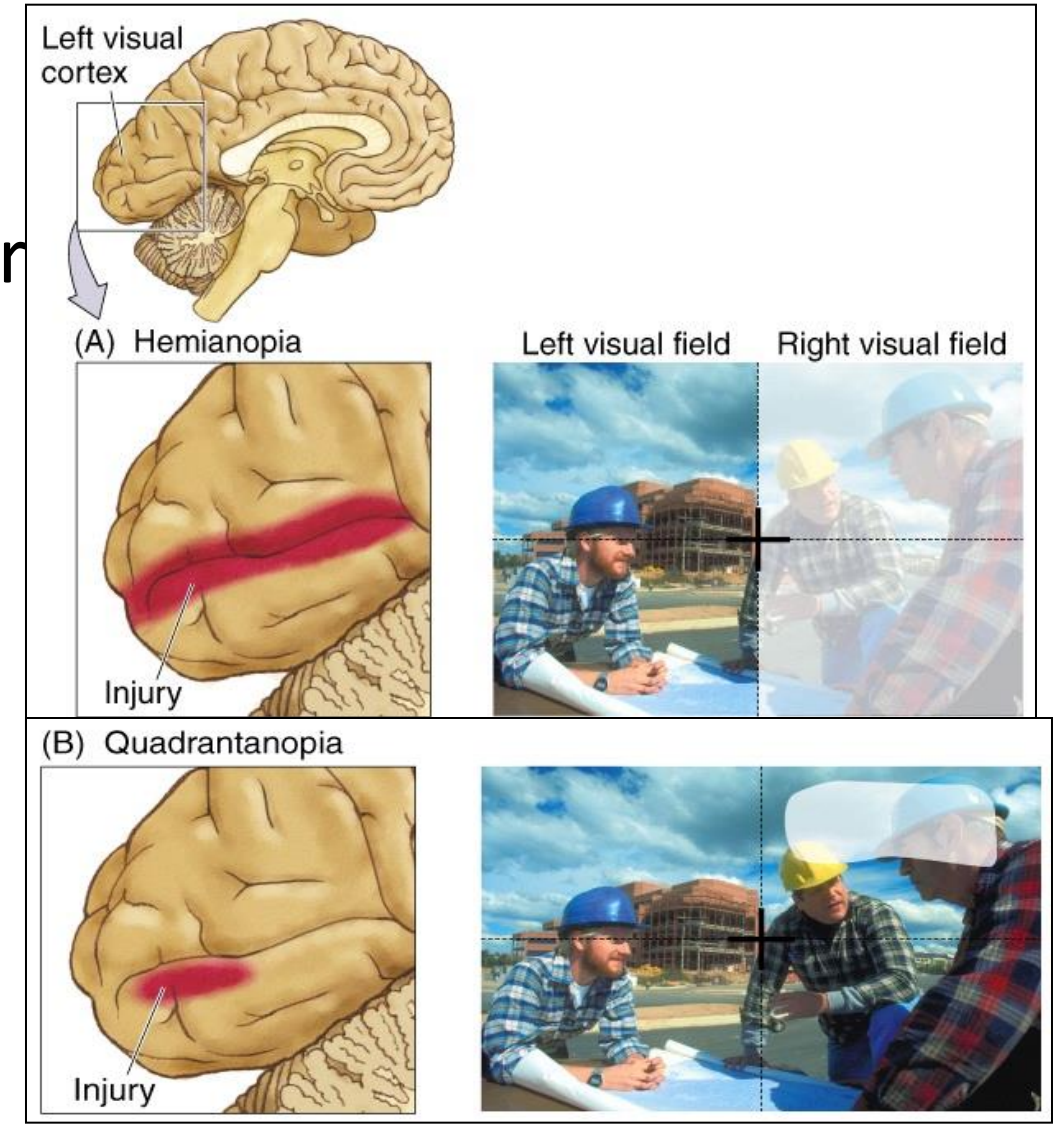
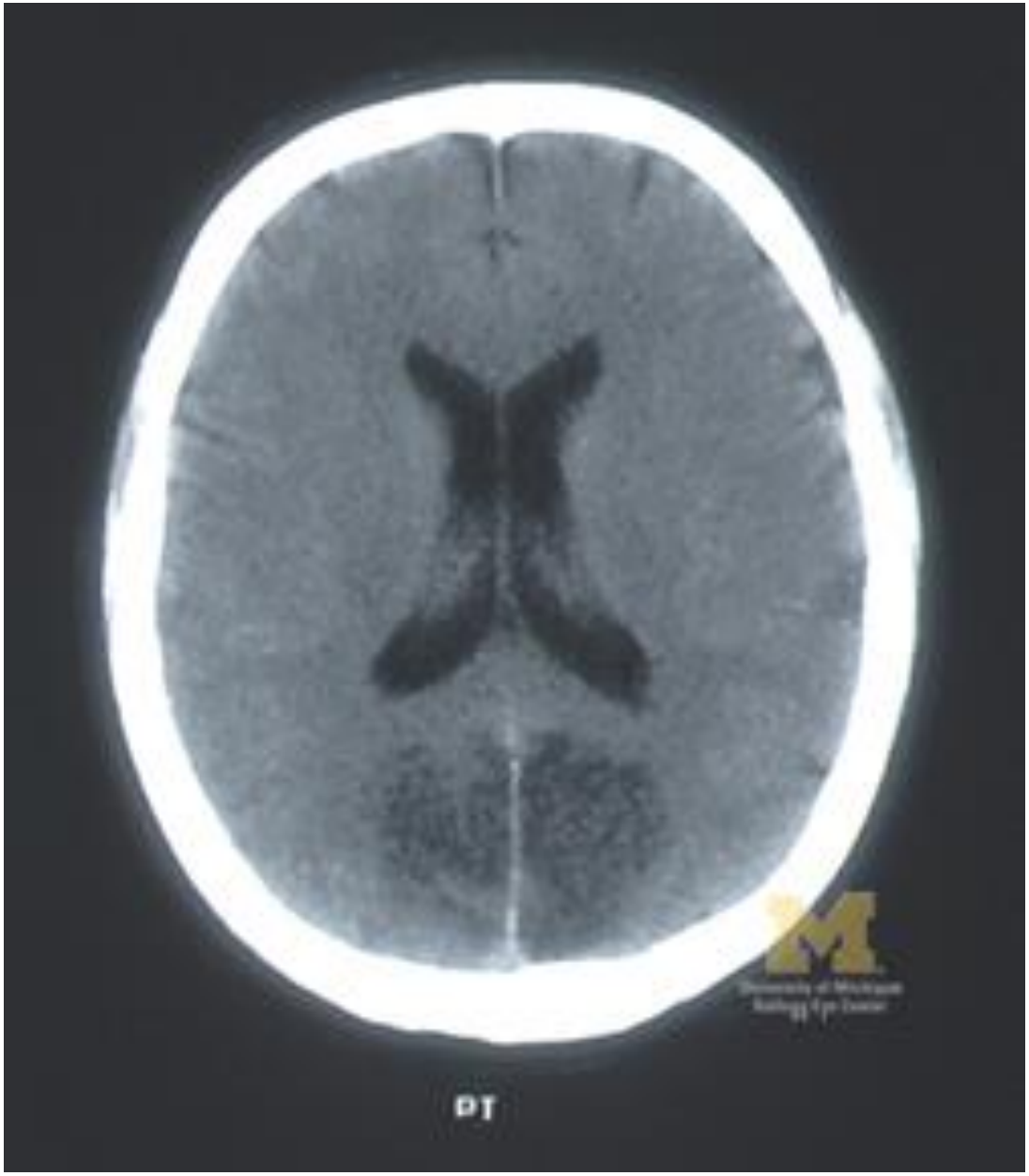


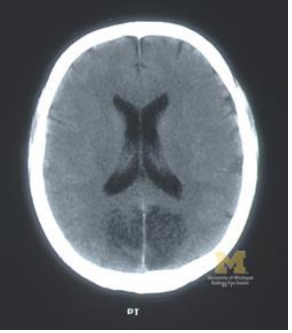


Lesions of the Visual Pathway

- **Hemianopia** – loss of pattern vision in either the left or right visual field
- **Quadrantanopia** – blindness in one quadrant of the visual field – damage to the optic tract, LGN or V1




PT



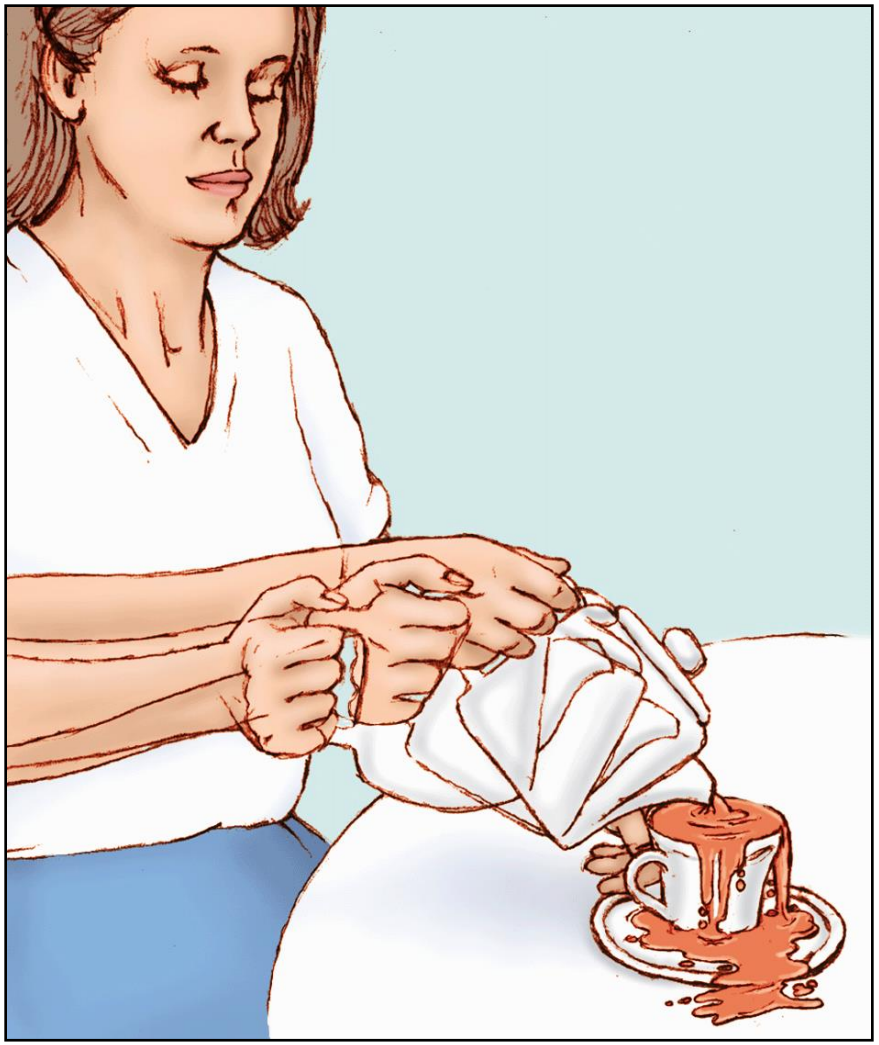
Anton–Babinski syndrome

(Visual anosognosia)

Gabriel Anton

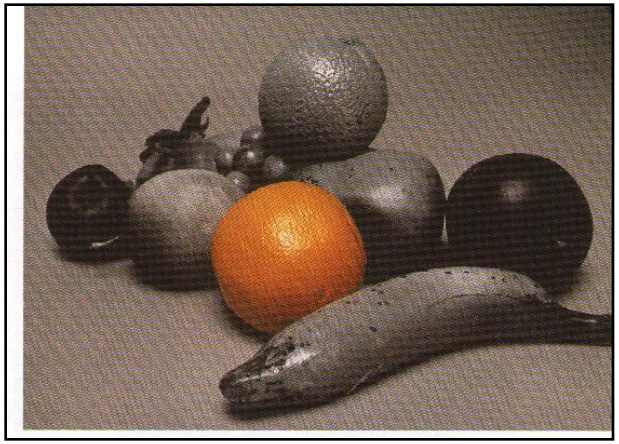
- Denial of blindness who cannot see.
- The lesion extend beyond the striate cortex to involve visual association areas.
- Failing to accept being blind, the sufferer dismisses evidence of his condition and employs confabulation to fill in the missing sensory input.
- Lesion is in visual association areas superior to calcarine cortex.

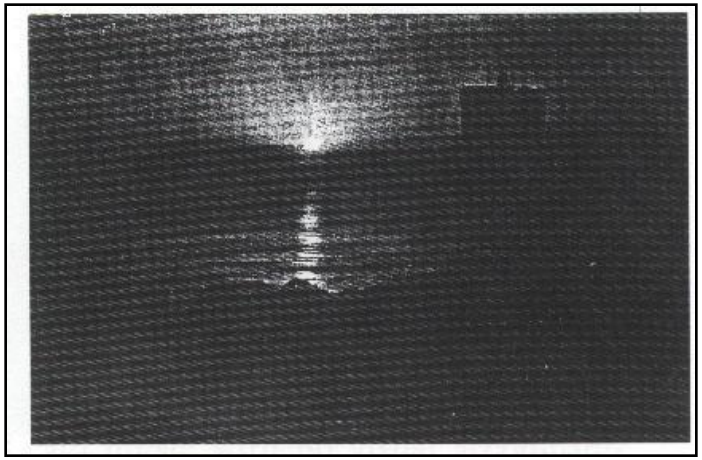
Deficits in Motion Perception: Akinetopsia



Deficits in Color Perception - Achromatopsia

- Congenital colorblindness (dichromats) vs. acquired colorblindness
- Usually associated with damage to V4
- Object recognition OK





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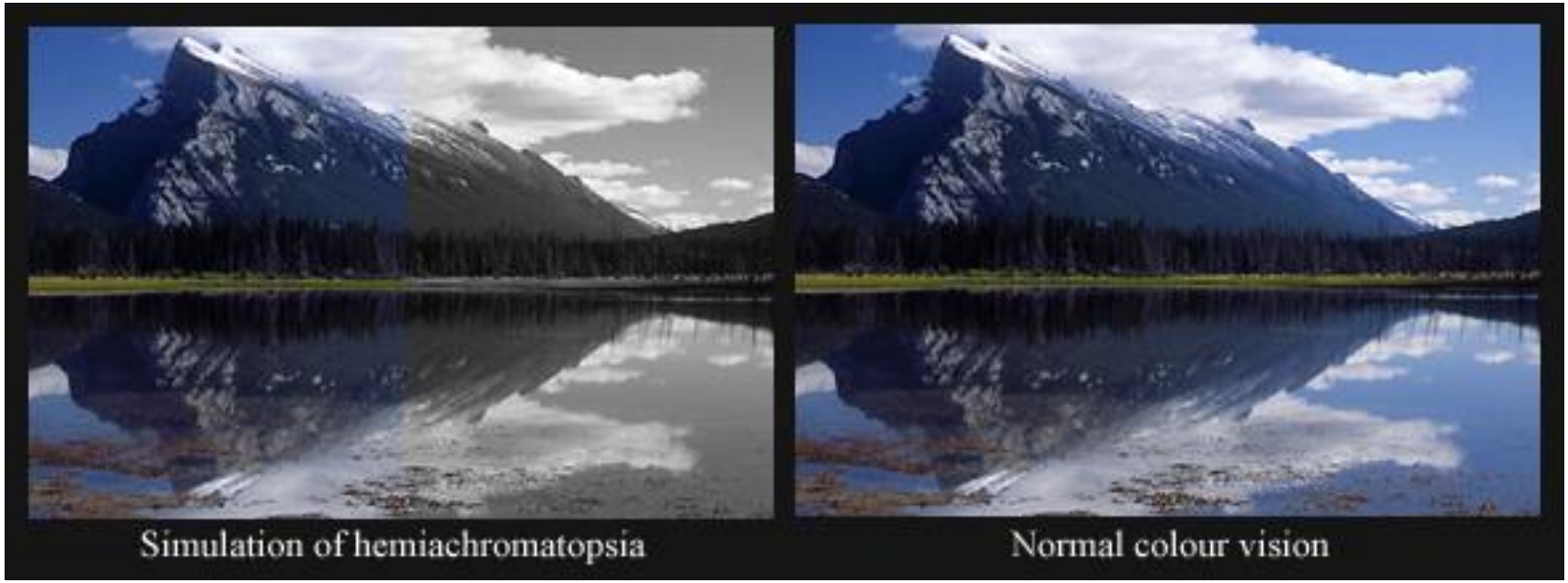
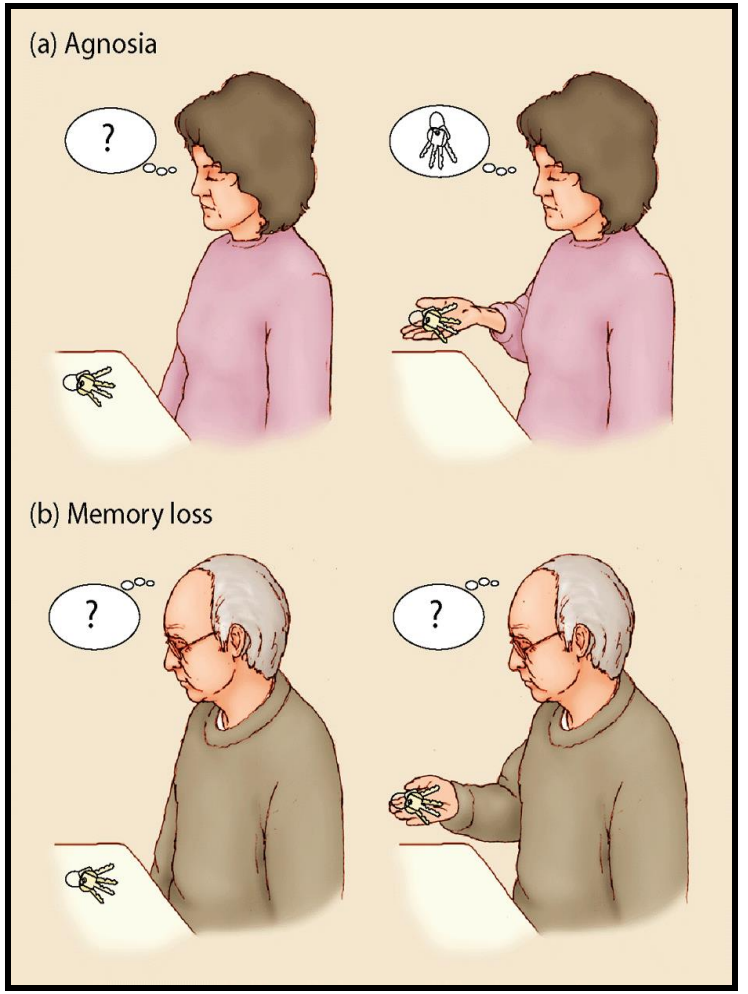


Deficits Following Damage to the WHAT Pathway

- **Visual agnosia** – partial or total inability to recognize visual stimuli, unexplainable by a defect in elementary sensation or reduced level of alertness or memory



Agenda

- Anatomy of visual pathway
- Visual pathway disorders
- Quiz

Agenda

- Anatomy of visual pathway
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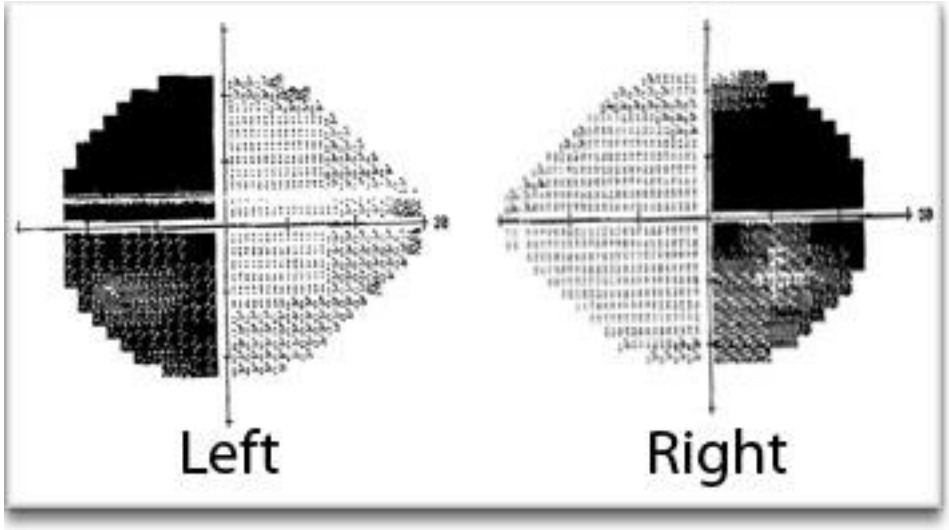
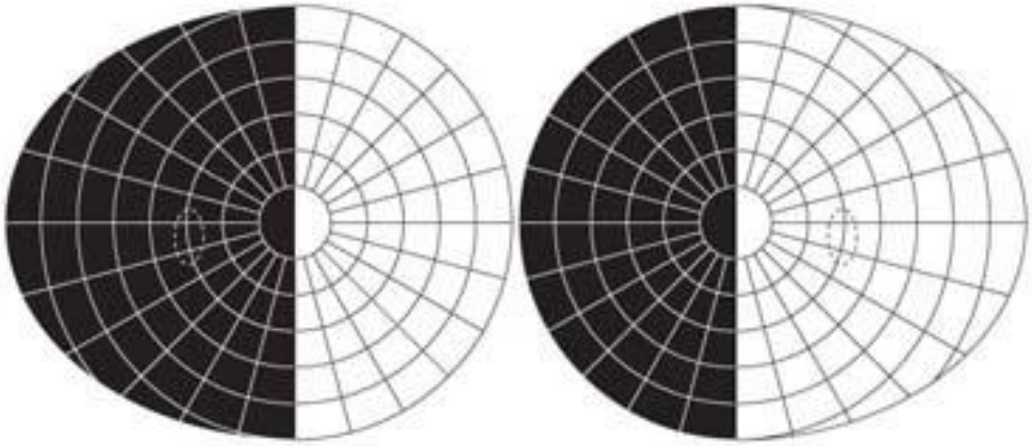
Describe the visual field defect ?



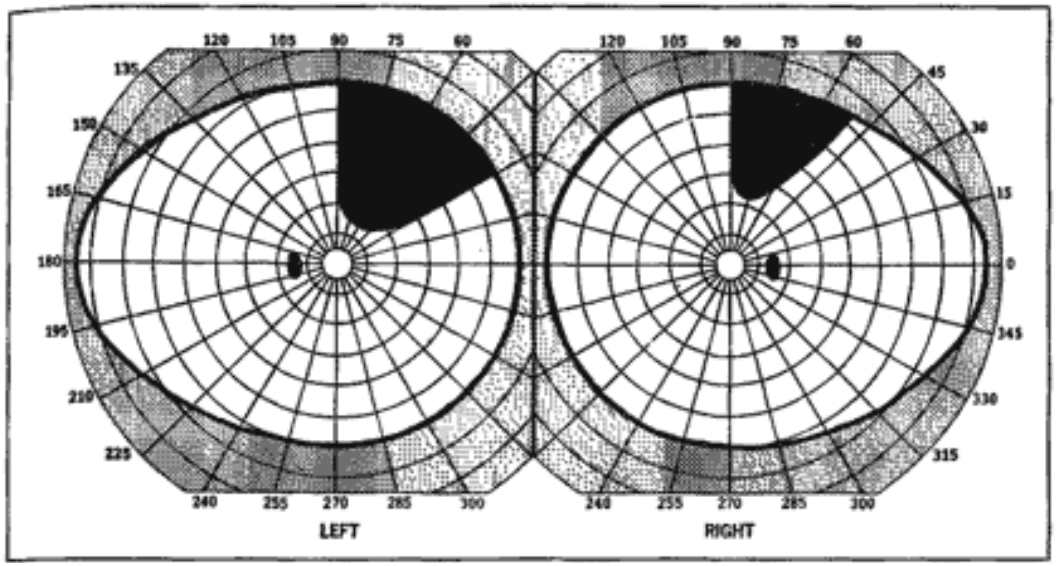
1

Describe the visual field defect ?



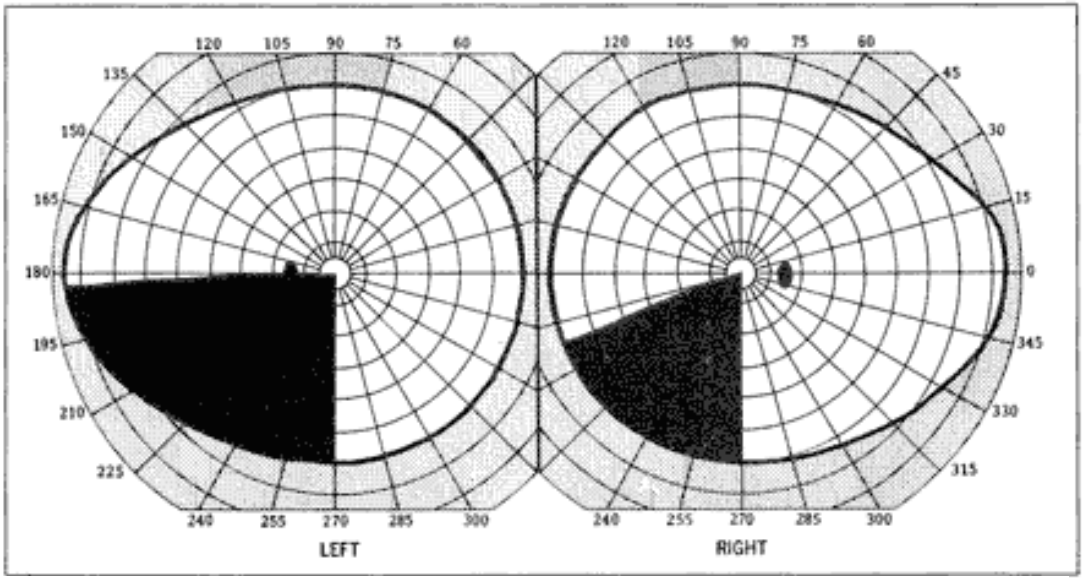
2

Describe the visual field defect ?



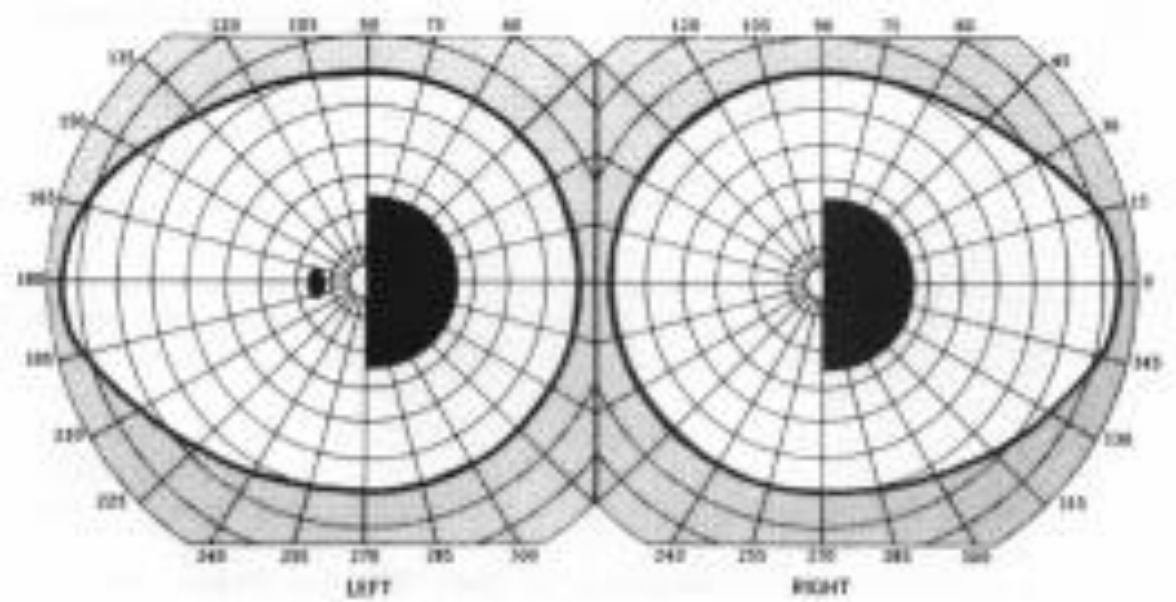
3

Describe the visual field defect ?



4

Describe the visual field defect ?



5

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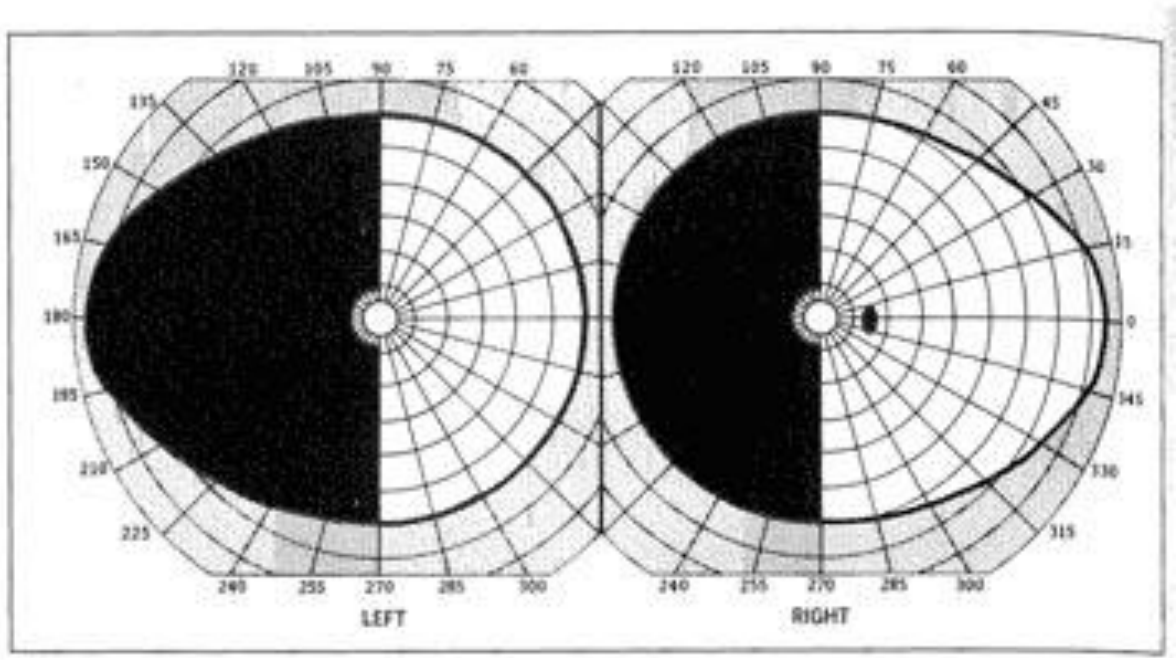
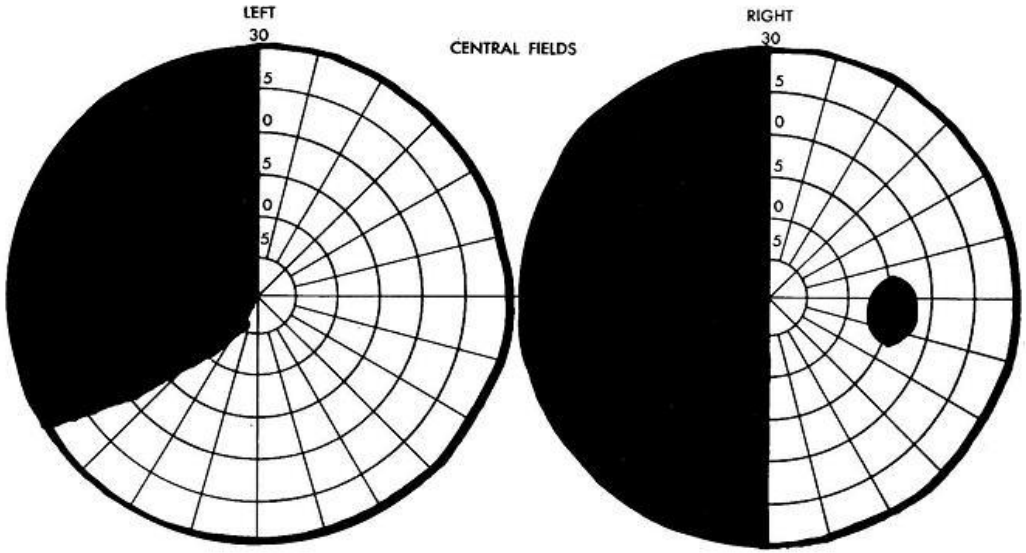


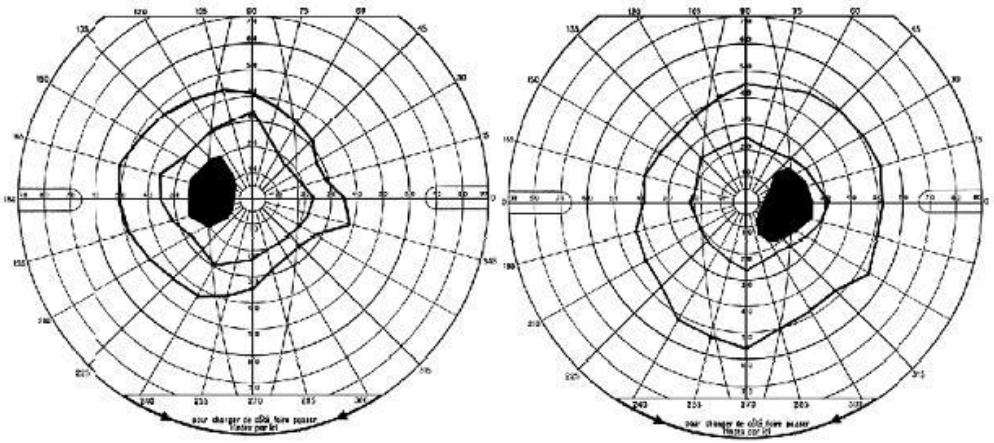
6

Describe the visual field defect ?



7

Describe the visual field defect ?

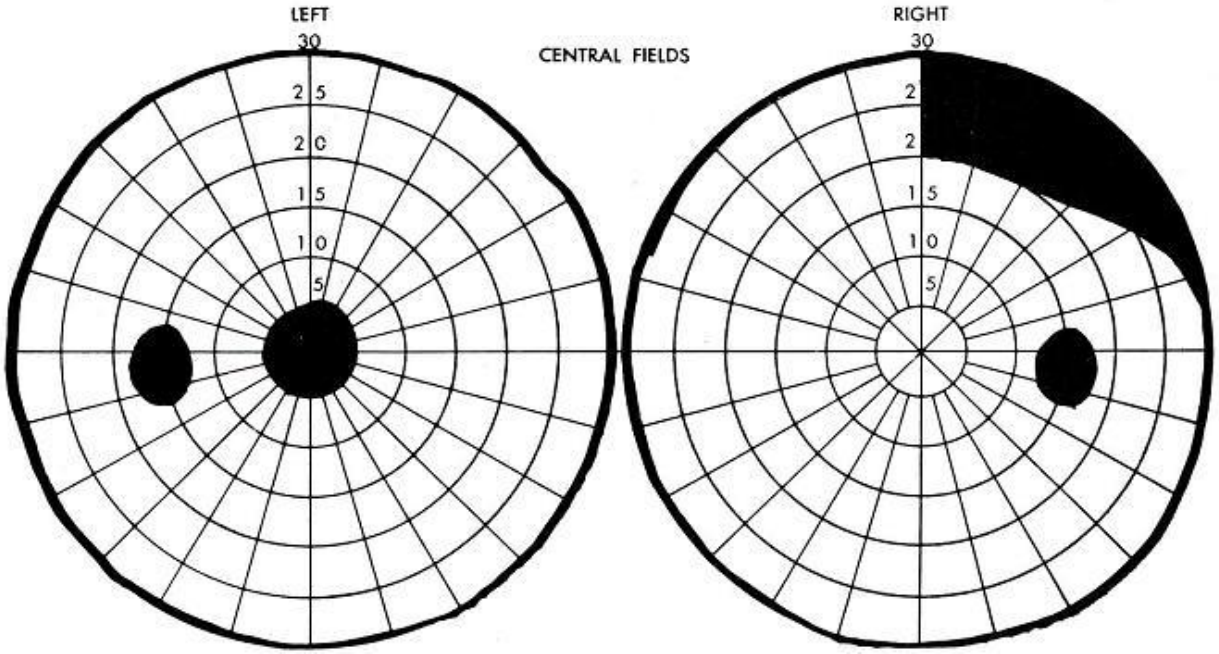


Left eye

Right eye

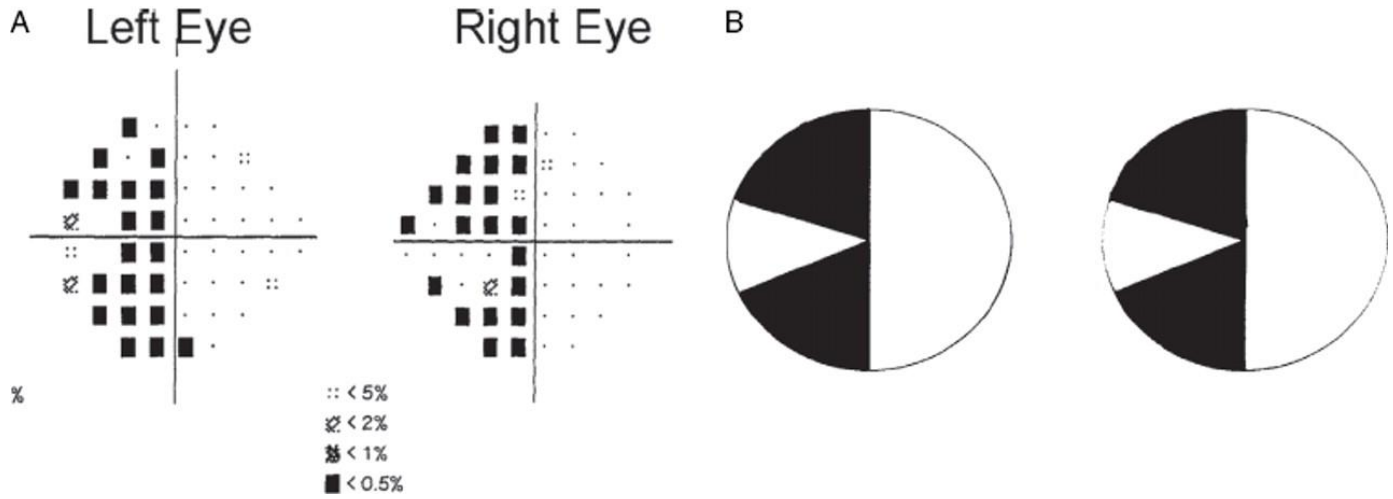
8

Describe the visual field defect ?



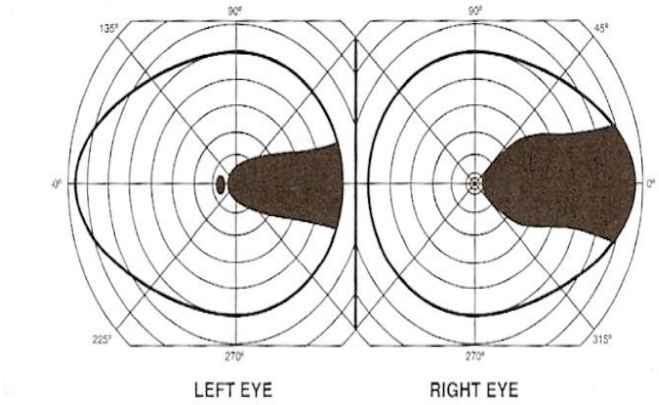
9

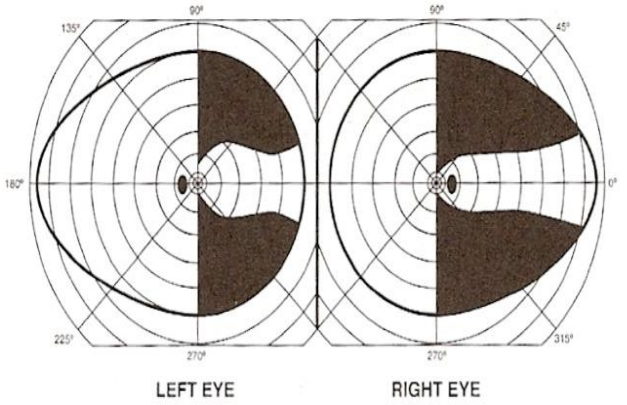
Describe the visual field defect ?



10

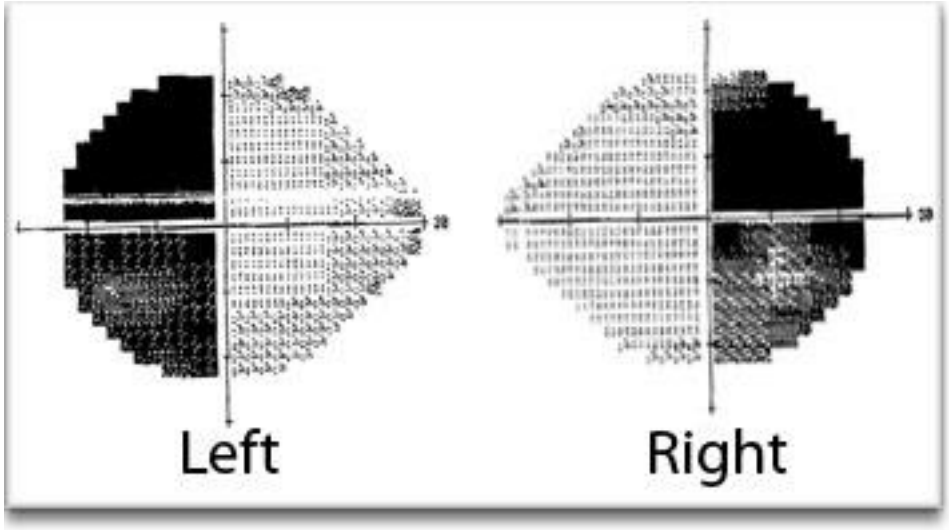
Describe the visual field defect ?





11

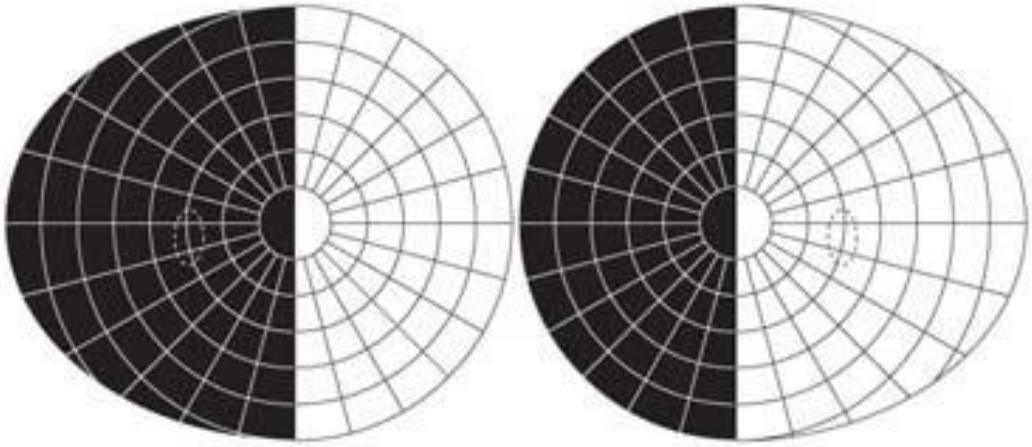
Describe the visual field defect ?



Bitemporal Homonymous Hemianopia

1

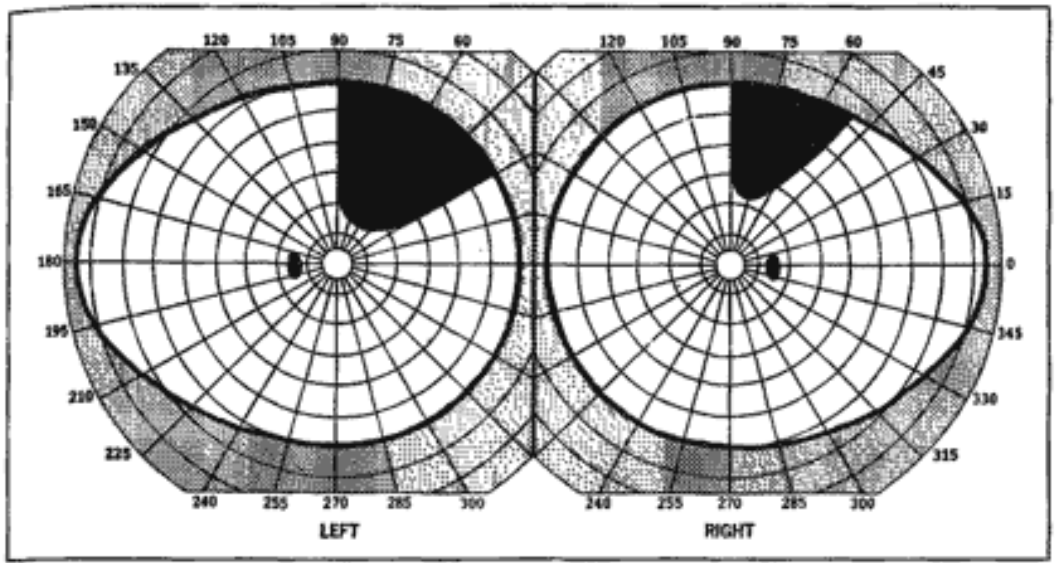
Describe the visual field defect ?



Left Homonymous Hemianopia

2

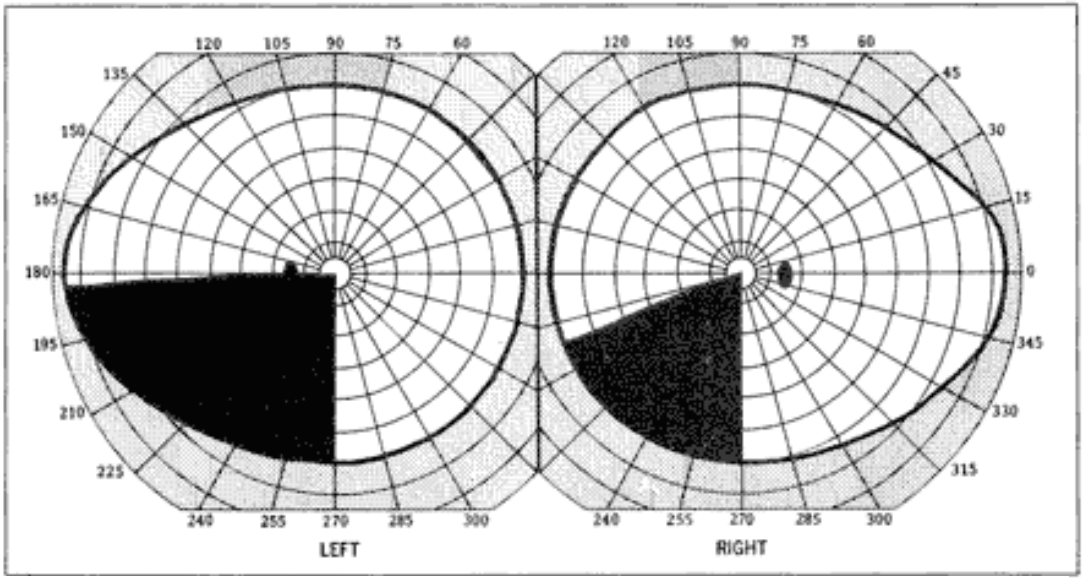
Describe the visual field defect ?



Right superior quadrantanopia >> temoporal lobe lesion

3

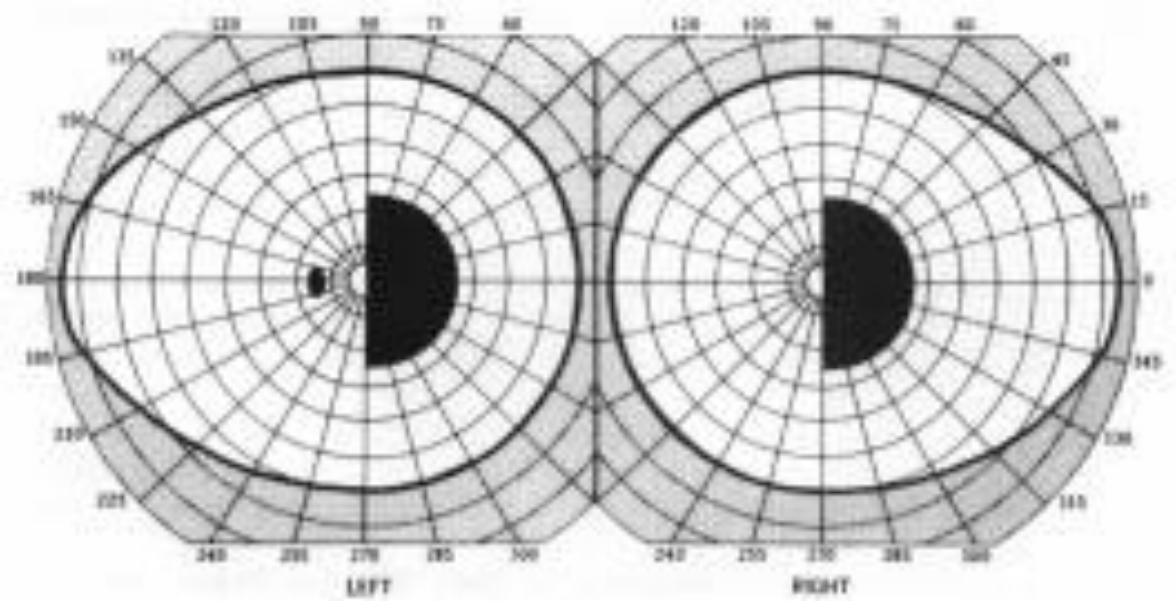
Describe the visual field defect ?



4

Left inferior quadrantanopia >> parietal lobe lesion

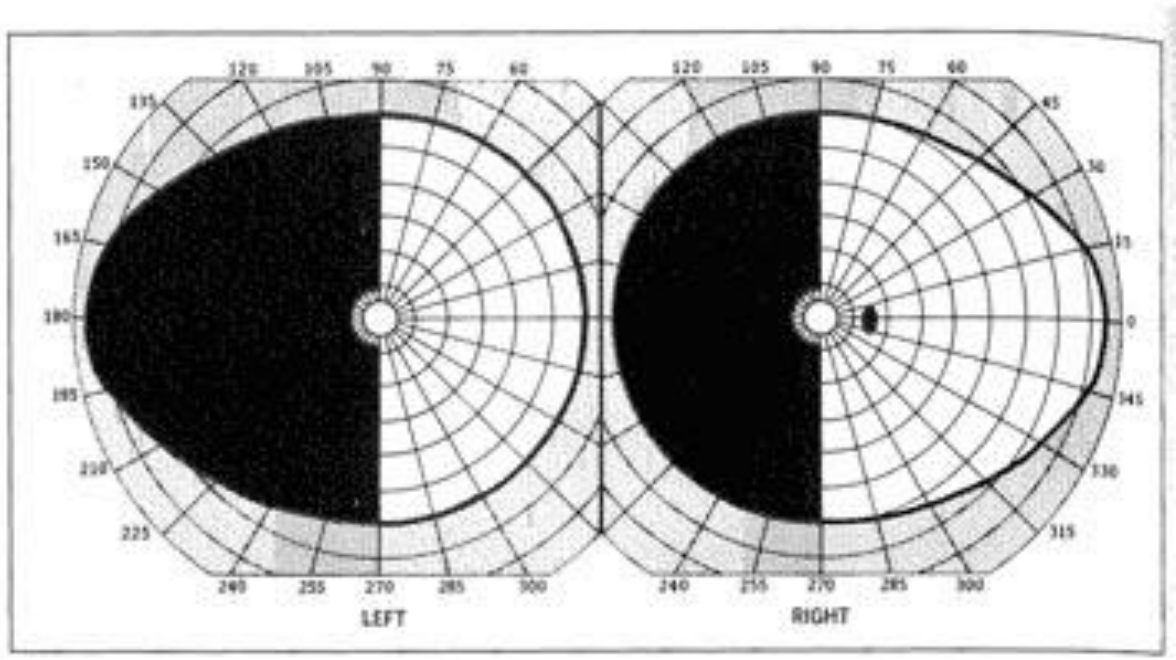
Describe the visual field defect ?



Right homonymous hemianopia

5

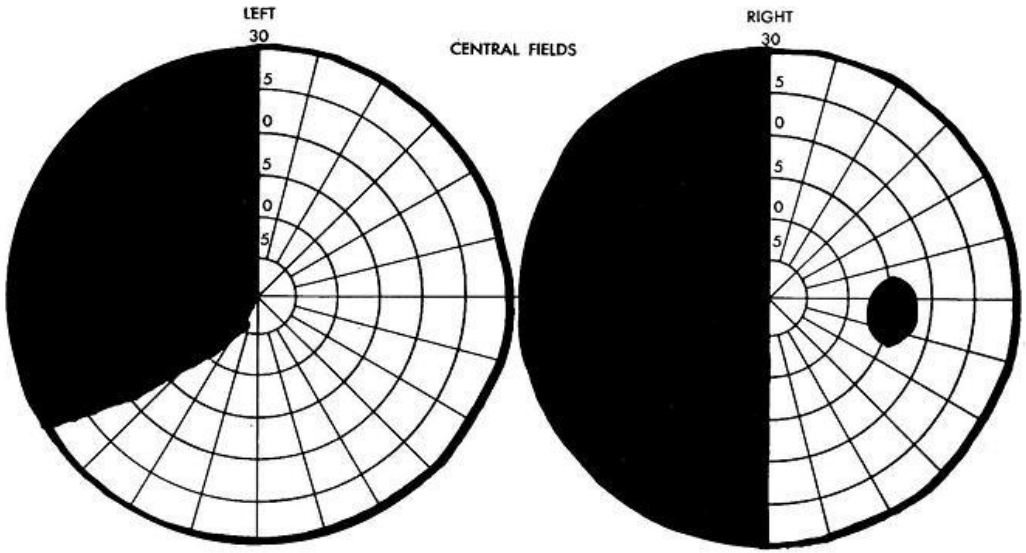
Describe the visual field defect ?



6

Left homonymous hemianopia with macular sparing

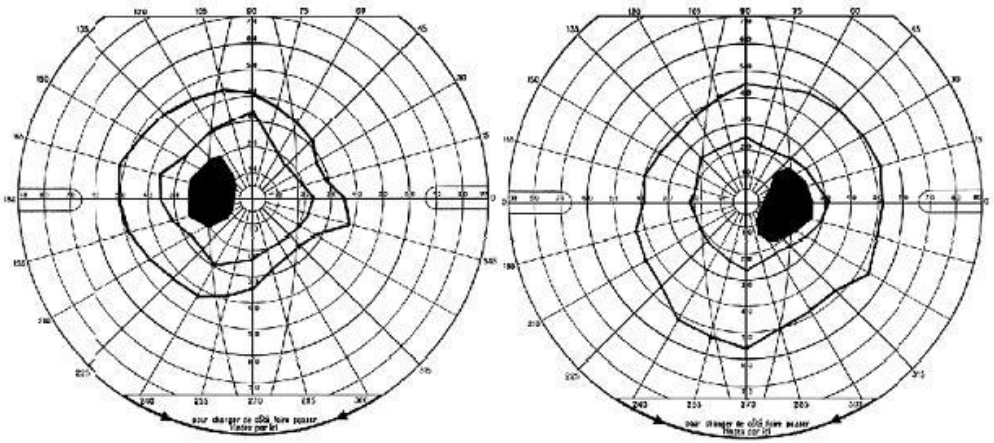
Describe the visual field defect ?



Left incongruous homonymous hemianopia

7

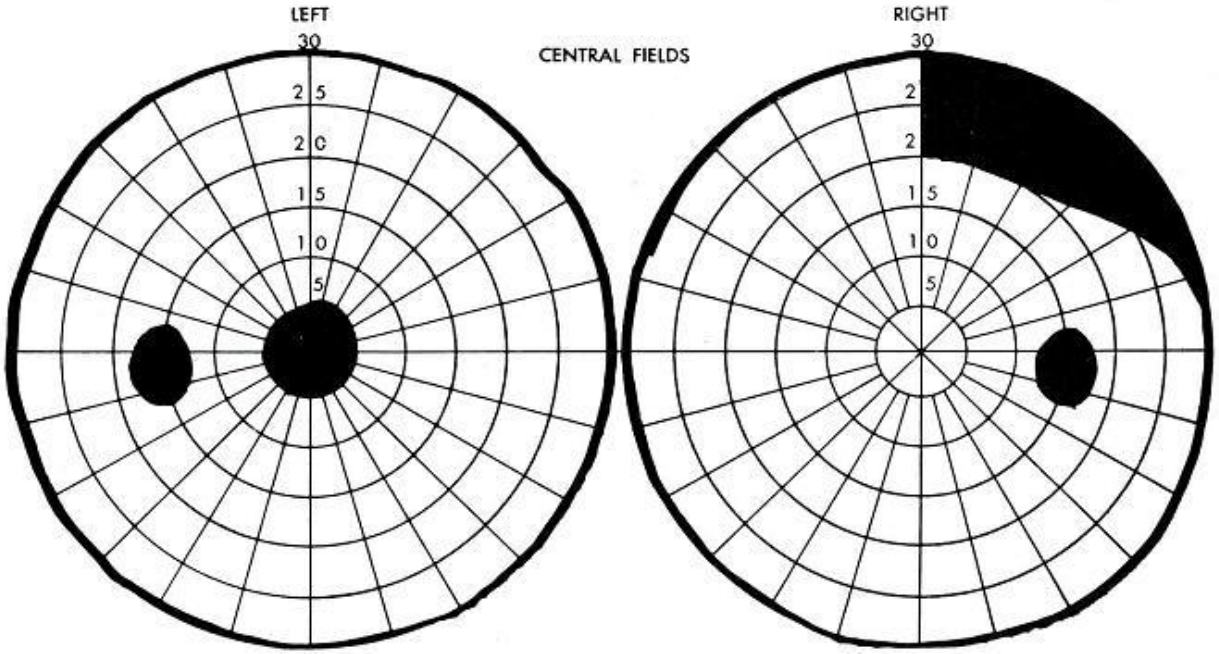
Describe the visual field defect ?



Left eye Right eye

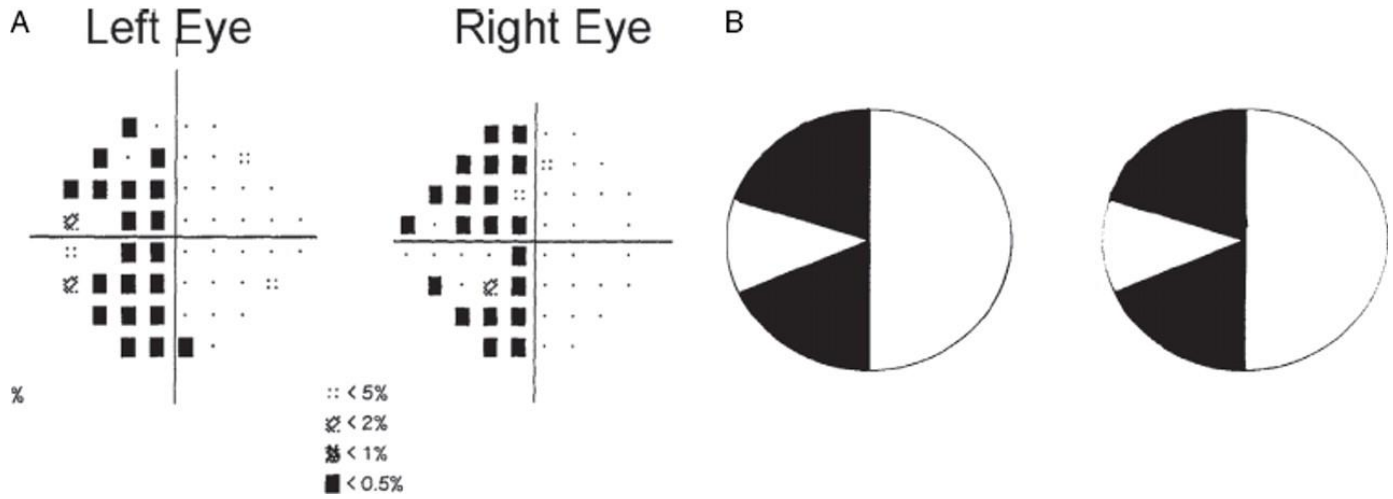
Enlarged Blind Spot

Describe the visual field defect ?



Junctional scotoma: lesion at junction of optic nerve and chiasm

Describe the visual field defect ?

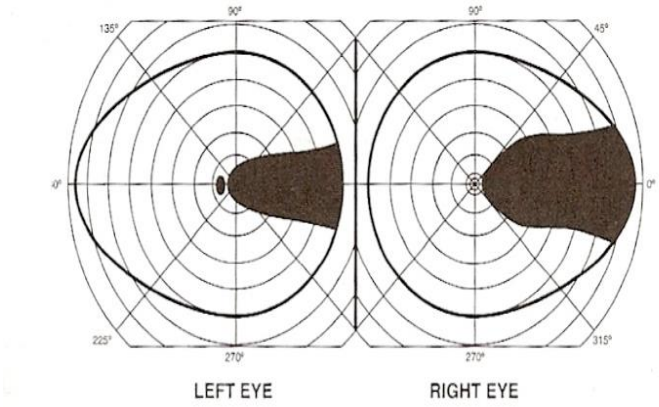


Left sector sparing homonymous hemianopia >> lesion at LGN.

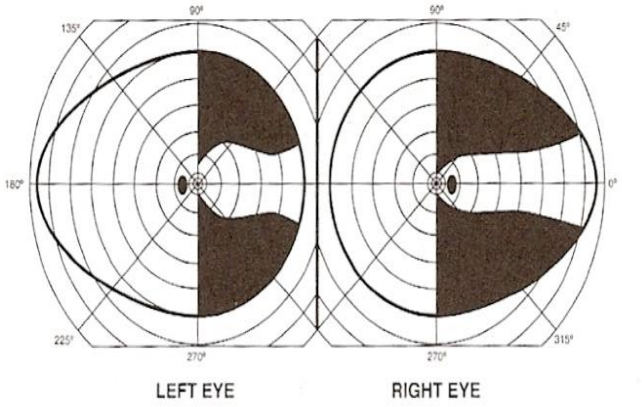
10

Describe the visual field defect ?

A.



B.



Describe the visual field defect ?

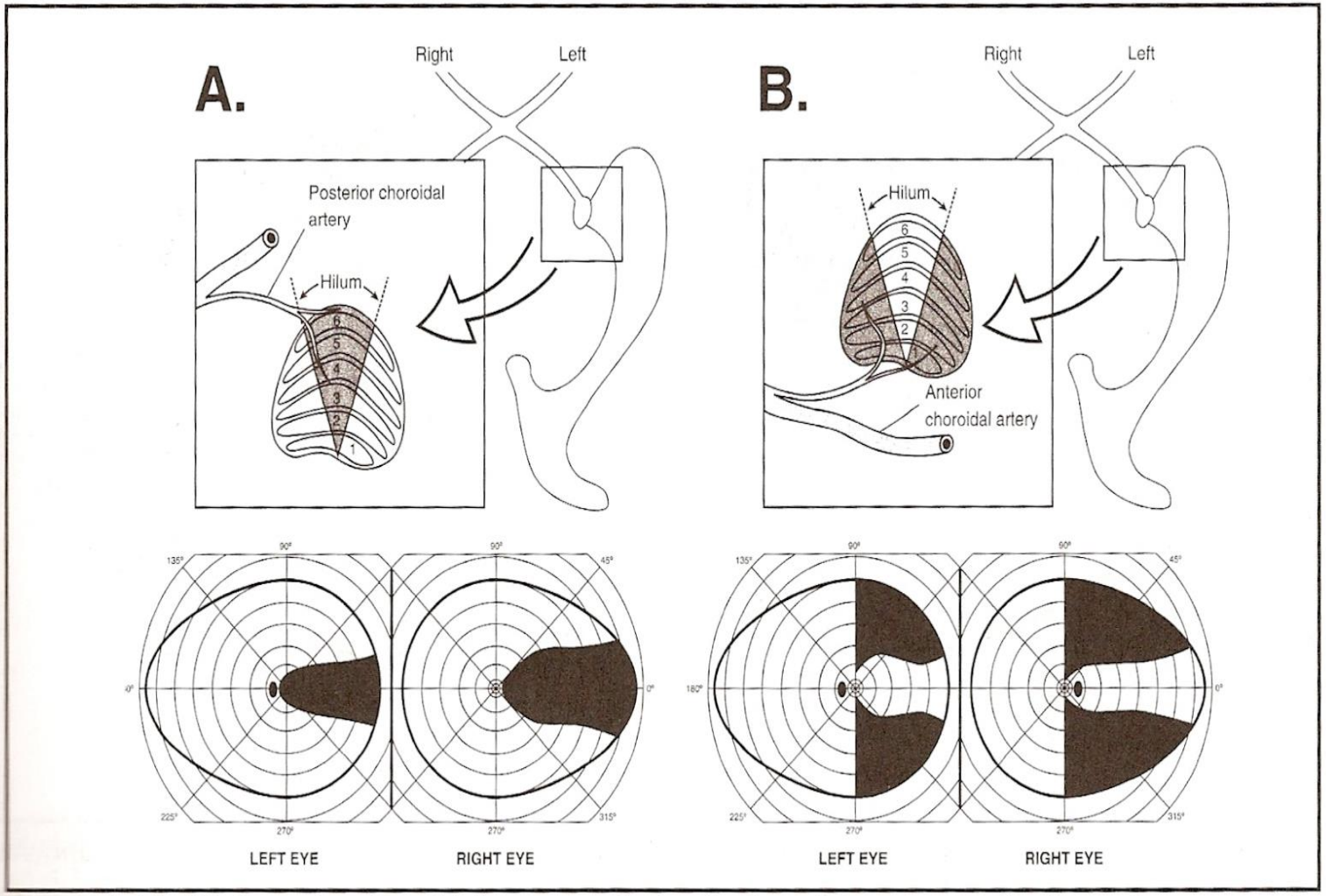


Figure 1-15. (A) Posterior choroidal artery occlusion leads to homonymous horizontal sectoranopia. (B) Anterior choroidal artery occlusion causes sector-sparing homonymous hemianopia.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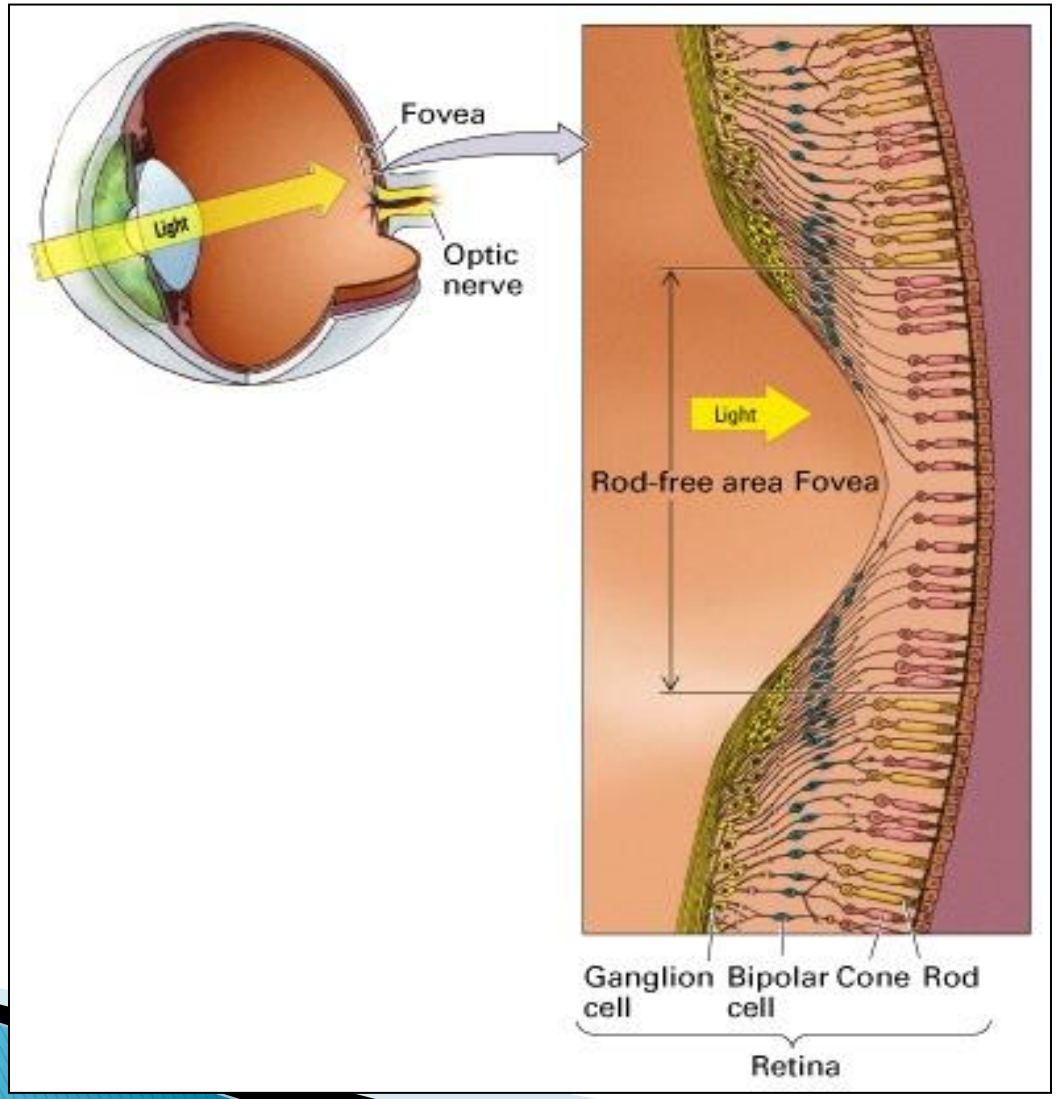
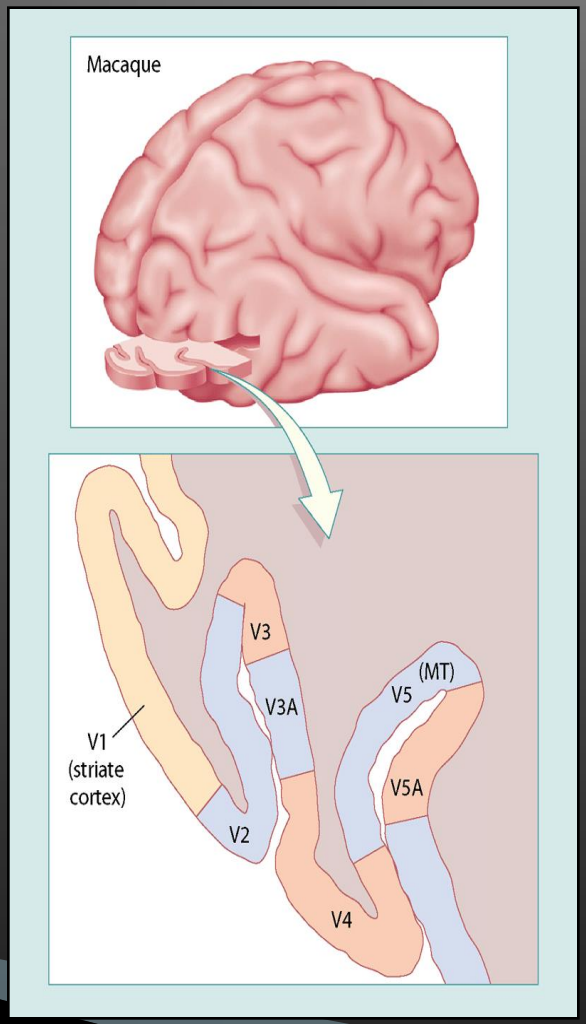
THANK YOU

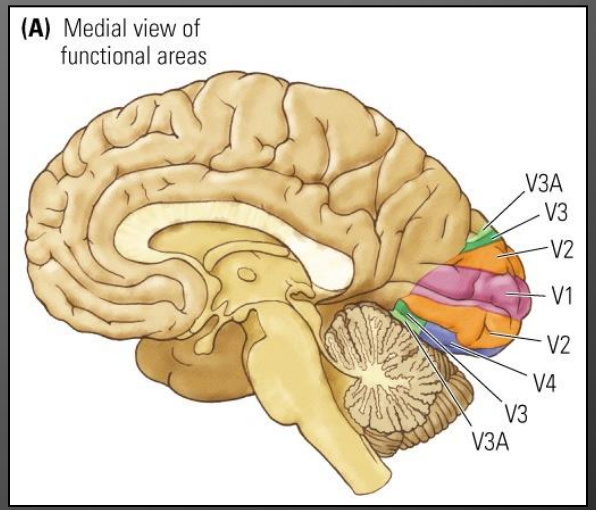
Eyes & Retina

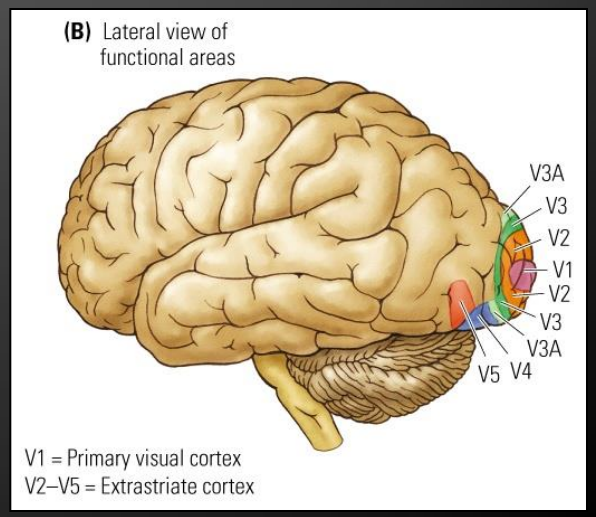

Fovea
Light
Optic nerve
Light
Rod-free area
Fovea
Ganglion cell
Bipolar cell
Cone
Rod
Retina

Visual Areas of the Cortex Outside the Primary Visual Cortex

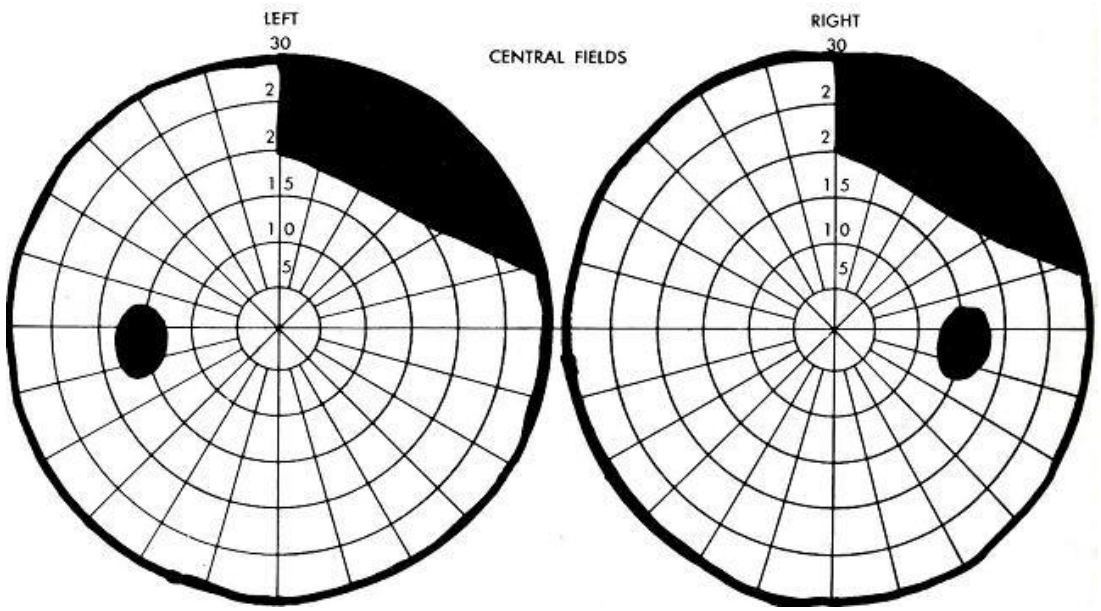
- ~30 cortical visual areas with distinct functions
- Each visual area has a topographic representation of external space in the contralateral hemifield (however, these get 'less' topographic as we get further up in the system)



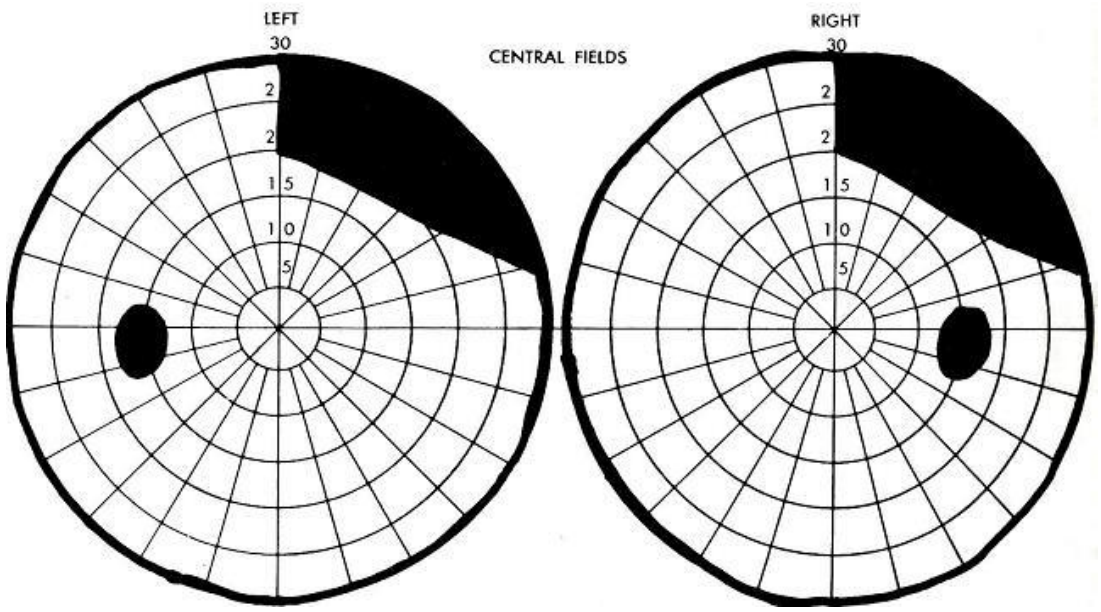




Describe the visual field defect ?



Describe the visual field defect ?



Right congruous homonymous hemianopia